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A
PRACTICAL TREATISE
ON THE
MEDICAL AND SURGICAL USES
OF
ELECTRICITY
INCLUDING
LOCALIZED AND GENERAL ELECTRIZATION.

BY

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FELLOW OF THE NEW YORK ACADEMY OF MEDICINE, MEMBER OF THE NEW YORK COUNTY MEDICAL SOCIETY;

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WITH ONE HUNDRED AND TWO ILLUSTRATIONS.

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TO

JOHN T. METCALFE, M.D.,

PROFESSOR OF CLINICAL MEDICINE IN THE COLLEGE
OF PHYSICIANS AND SURGEONS,

THIS WORK IS DEDICATED,

WITH THE GRATEFUL ESTEEM

OF THE

AUTHORS.

32116

PREFACE.

THE object of this work is to present, in a compact, practical form, all that is now known on the application of electricity to the treatment of disease. The aim of the authors has been to combine their own extensive and varied researches with localized and general electrization, and the labors of all other recent explorers in electro-therapeutics, in a summary which should be at once practical and exhaustive, and which should represent with strict impartiality all that has been really accomplished in this department by every school, in every country, and by all methods.

For this undertaking the authors have been prepared by an experience acquired in more than 10,000 applications of electricity in a wide variety of morbid conditions, and by personal observation of the methods and the results of the recognized leaders in this important field of science.

For convenience of reference, and in order to avoid repetition and confusion, the work is divided into *Electro-Physics*, *Electro-Physiology*, *Electro-Therapeutics*, and *Electro-Surgery*. It is believed that by this arrangement the work will be more acceptable both to the majority who seek to consult the distinctively practical portions, and to the few who may desire also to investigate the subject of electricity in its physical and physiological relations.

General electrization, which the authors were the first in the profession to systematically investigate, is here, for the first time, described and illustrated in systematic detail of its modus operandi and its very remarkable effects in conditions of debility.

To central galvanization, especially galvanization of the sympathetic—for which the laborious school of Remak have laid the profession under great obligations—has been accorded an attention and a prominence to which, by its growing importance, it is certainly entitled.

The general differential indications for the use of the two currents and for the use of localized and general applications, we have sought to distinguish and elucidate by logical deductions from the known principles of electro-therapeutics, and, above all, from extended experimental comparison. The knowledge of electro-therapeutical anatomy, which is so essential for an intelligent electro-diagnosis in therapeutics, we have endeavored to facilitate by concise and explicit illustrations. The drawings for illustrations of the different methods of electrization were made from photographs taken during the applications.

In the selection and detailed description of apparatus, both the tastes of the specialist and the imperative needs of the general practitioner have been constantly borne in mind; and while nearly all the most improved forms of machines for both currents have received notice, minute description and illustration have been reserved only for those that experience has shown unite in the highest degree the qualities of convenience and compactness, with accessibility and uniformity of action. When we began our experiments in this department, there was in this country no satisfactory apparatus either for the faradic or the galvanic currents, and for this reason our early observations were made under exceeding disadvantages.

The difficulty has for a number of years been partly met by the electro-magnetic apparatus of Kidder, which, for all the essential qualities required, is as yet unsurpassed. We early became convinced that scientific electro-therapeutics required also a galvanic apparatus which should be at least more compact and more portable than those which had been usually employed, and that to be forced to depend on apparatus of foreign construction would both retard the progress and practically prohibit the popularization of electro-therapeutics. Amid many discouragements which only those who have pursued similar investigations can well appreciate, we have striven to overcome this serious evil and to prepare a galvanic apparatus which should be both simple and enduring, and which could be used at the bedside as well as in the hospital or consulting-room. Through the skill and intelligence of the mechanician above-mentioned, we are now able to present an apparatus for the galvanic current which, if not on the one hand so compact, or on the other so elaborate as others to which we have called attention, is yet, in the wide variety of size and shape of which it is capable, in the simplicity of its construction, and the ease of its management, perhaps even better fitted to supply the general want.

Electro-surgery, though a young and as yet but little developed branch of electro-therapeutics, is yet of such intrinsic importance and interest, and so fruitful in promise for the future, that it has been deemed worthy of separate and special consideration.

In the preparation of the detailed and statistical reports of cases, we have sought to give a picture that shall be so accurate, and so true to experience, that it may be unfailingly recognized by all those who pursue a similar line of experiment. The somewhat deserved reproach against electro-therapeutists, that they publish only their most fortunate results, we have endeavored to avert by giving prominence to failures as well as to successes; by noting relapses as well as permanent recoveries. We have been not unmindful of the fact that statistical reports of the results of any method of treatment, however conscientiously prepared, must be at best incomplete, and to a certain extent illusory. Therapeutics is always a subject of vast complications. It is probable that in some of the cases reported as absolute or approximate recoveries, nature and time, and in a few instances, perhaps, other medicinal or hygienic treatment bore as large a share as the applications themselves. We have, however, endeavored to make all proper allowances for the influence of these various factors; and in the few exceptional cases where medicinal has been combined with electrical treatment, the fact has been mentioned, and cases of positive doubt have been excluded from consideration. For the study of the special effects of electrical treatment, when used alone, we have been peculiarly fortunate, since the vast majority of our cases had abandoned medication before they were referred to our care. On the other hand, it is indisputably true that some of the cases reported as absolute failures, or as but slightly benefited, were kept from perfect recovery by the indulgence of evil habits of hygiene; and it is fully probable that some of them, as well as of those reported as unknown, appreciated the after results of the treatment and went on to recovery. Still further, it is in every way probable that some of the failures might, by greater perseverance on the part of the patients, have been transformed into perfect successes.

It is believed that these various errors to a certain extent counterbalance each other, and that on the whole our statistical reports fairly represent, so far as they go, the legitimate results of the electrical treatment. And yet it should be considered that the majority of the cases represented in our statistics were both long-standing and peculiarly obstinate, and there is ground for the belief that those who treat milder and more recent cases by the same methods, will obtain a larger percentage of success.

It will be observed that throughout the work these leading ideas are kept constantly in the foreground as the foundation principles on which must rest the science of electro-therapeutics:—

1. That electrization, besides being merely a local stimulant, also exercises an influence over general and local nutrition, at once unique and unrivalled, and that entitles it to the highest rank among constitutional tonics.

2. That the accepted system of making the applications exclusively local is both illogical and inconsistent; that in the use of electricity, as of every other remedy, constitutional diseases should be treated constitutionally.

3. That the best method of bringing the whole system under the direct influence of the current is by general electrization as here described; and that by the use of this method the success of electro-therapeutics is materially enhanced, and its sphere very greatly widened, so as to include a variety of frequent and distressing constitutional morbid conditions, for which merely localized electrization is but imperfectly indicated.

4. That, in determining the influence of the electrical applications on conditions of disease the last appeal must be made, not to physics nor to physiology, nor to pathology, nor to any *à priori* reasoning whatever, but solely and alone to clinical experience.

To those who adhere to the long-accepted theory that electricity is merely a means for local stimulation, and, as such, chiefly indicated in the severe or incurable conditions of paralysis or chronic rheumatism, or who hope to reduce electro-therapeutics to an exact science on the basis of a complete physiology and pathology, the above propositions must seem both radical and erroneous, and especially so if they have studied the action of electricity on the body merely by localized applications.

Therefore with all the greater interest and pleasure have we observed that during the last few years, there has been in electro-therapeutical literature a manifest and increasing tendency to abandon the narrow doctrines of merely local stimulation, to accept the fact which experience everywhere confirms, that in electricity we have an unsurpassed means of improving the general nutrition in the immense variety of chronic morbid conditions where such results are chiefly indicated; and we express the confident hope that the abundant and varied evidence with which in the present work we have been enabled to fortify these propositions, increased and enriched as it may be by the experience of the future, and harmonizing as it surely must with the general progress of science, will materially aid in bringing nearer the day of their universal acceptance.

Although this work is not intended to be in any sense a complete guide to the study of chronic diseases of the nervous system, yet some general remarks on the nature, causation, and the diagnosis of the principal of these diseases have been deemed both appropriate and necessary, for the twofold reason that such knowledge is necessary for an intelligent appreciation of the directions for the treatment, and also because very many of the diseases here mentioned—such as nervous dyspepsia, spinal irritation, neurasthenia, hypochondriasis, insomnia, locomotor ataxy, muscular atrophy, spinal and infantile paralysis, as well as some of the varieties of neuralgia—have not received in any one popular text-book the practical attention which their vast importance in electro-therapeutics requires.

Scientific electro-therapeutics requires scientific diagnosis. He who only knows how to apply electricity is not fit to do even that. Successful results in electro-therapeutics can be and are obtained by the most ignorant of charlatans, but to intelligently report these successes or make them of value to science requires the best skill of the physician. Mere hand-books of electrical applications cannot be otherwise than injurious to science. Other conditions being the same, the value of reports of cases in electro-therapeutics is in direct proportion to the accuracy and completeness of the diagnosis. For this reason it is that electro-therapeutics is the most exacting and laborious of all the special departments, for in a certain sense it trenches on and necessitates a knowledge of all other departments.

In the strict sense of the word, therefore, the electro-therapeutist is no specialist, since his ideal—which of course he can but imperfectly fulfil—must be to know something of every department with which electro-therapeutics brings him into relation. His ambition, like that of Bacon, must be "to make all knowledge his province."

Besides a thorough familiarity with the department of nervous diseases, and especially with the recent methods of studying them by the æsthesiometer, the ophthalmoscope, and by electricity, it is necessary for the electro-therapeutist to avail himself of all the advances that are made in the special departments of gynecology, ophthalmology, otology, laryngology, and dermatology, as well as general medicine and surgery.

In respect to diagnosis we have ourselves been exceptionally favored, since the majority of our cases have obtained the opinion of one or more acknowledged authorities in their respective departments.

That all the special views on the nature and treatment of the diseases here mentioned should meet with universal acceptance, is more than can be expected. Everywhere we tread on debatable ground. In regard to the nature, the causation, the symptoms, the general treatment, the divisions and the terminology of diseases, the choice of currents, the methods of applications, the relative merits of rival apparatus,—in these and in many other subjects there is room for the widest possible divergence of honest opinion among those whose abilities and opportunities entitle their opinions to the highest respect. On all these controverted themes we present nothing as a finality, nothing which we shall not readily modify in the light of sufficient iuductive evidence.

More than almost any other department, electro-therapeutics has suffered from its terminology. So large is the number of synonyms, and so indefinite the meaning of many of the words and phrases which have come into use, that intelligent conversation on the subject has been well-nigh impossible. This crying evil, from the first, we have sought to rectify, and with this view we have resolutely and uniformly distinguished the two currents as *faradic and galvanic*, discarding entirely their various and complex synonyms. It is believed that this and other changes which we have made are in the direction of simplicity, and that they will shorten the labors of the student, and will serve to recommend rather than repel the earnest inquirer.

It will be observed that in this work the future as well as the past has been regarded, and that a number of diseases are mentioned, for the sake chiefly of the promise and the hope which they offer for electro-therapeutics. The object of such mention is to inspire authorities in the several departments to co-operate with electro-therapeutists in the important and difficult task of submitting these diseases to faithful and rigid experiment, and to those who may be induced to do so we beg leave to offer these suggestions:—

First. That they do not suffer themselves to be misled or in any way controlled by theoretical reasoning. Already the advance of electricity into the domain of medicine has been retarded, at least a quarter of a century, by erroneous or undemonstrable theories concerning the action of electricity or the nature of diseases, or more recently by futile attempts to make electro-physiology a sufficient basis for electro-therapeutics. It cannot be too often repeated, that *the essence af electro-therapeutics is clinical experience.* Electro-physiology is a science at once noble, interesting, and suggestive, but in its relations to electro-therapeutics, with very few limitations indeed, it should follow rather than precede, should explain rather than guide.

Secondly. That they do not confine their attention too exclusively to diseases which have a merely pathological interest. We but represent the growing sentiment of the ablest medical thinkers of our time, when we assert that in recent days, in nearly all departments, therapeutics has been sacrificed to pathology, and that diseases, however prevalent, and however painful, which offer no interesting pathological history, are practically neglected. Now it is safe to assert that in this country at least, there is immeasurably more suffering in the higher walks of life from the somewhat indefinite condition known as nervous dyspepsia than from all forms of paralysis combined; and any remedy which, like general electrization, promises almost sure relief for this condition, and which at the same time, by its powerful effects over nutrition, tends to prevent or delay the visitation of incurable central lesions, is surely worthy of careful study. It is especially unfortunate for the student of chronic diseases of the nervous system that nearly all the works on practical medicine have been of foreign authorship, and have been based on hospital rather than on private practice; for the types of disease are modified by social position and occupation as much as by race or climate, and the nameless symptoms associated with chronic nervous exhaustion which are found in every family among the higher walks of American society, and in greater variety and severity than in any other country, should receive the earnest attention of all practitioners, if necessary even to the exclusion of the rare and exceptional pathological cases to be found in our public institutions, however interesting or suggestive they may be. As will be seen in the course of the present work, this class of cases are, of all others, the most amenable to electrical treatment, and therefore demand the special study of the electro-therapeutist. Withal it should be remembered that electro-therapeutics has not been entirely useless to pathology, since, in obscure cases, the locality if not the precise nature of the disease, is indicated by the results of treatment.

Thirdly. That unfavorable as well as favorable results be accurately reported. Every failure which is published in detail is, in one way, as much a fact for science as a success, since it reduces and guides the labors of future experimenters. In our estimate of any remedy, it is important that we should know its weakness as well as its strength. Those who know the most of electricity in its relations to medicine will be the last to regard it as an unfailing specific.

If investigations are everywhere pursued in this spirit and by those most competent to make them, the reproach of Mr. Lecky, that "The medical powers of electricity, which of all known agencies bears most resemblance to life, are unexplored," will cease to be deserved.

To all who for the first time enter upon the study of this branch of science, we cannot too strongly recommend the practice of *self-experimentation.*

Better than any experiments on animals, better even, in many features, than extended investigations in the treatment of disease, is the precise and peculiar knowledge of the modus operandi of the applications, and the sensations which they produce, which is obtained through personal experience.

Compared with internal remedies, electricity has the great disadvantage that, on account of the necessary mechanical and technical difficulties in the way of its successful employment, it cannot be rapidly popularized. Drugs for internal administration, like bromide of potassium and hydrate of chloral, can spread over the earth in less time than is required even for the specialist to master the elements of electro-therapeutics. There is little doubt that if electricity could be given in the form of pills or powders as successfully as it is now employed, its use would be increased one thousand-fold.

Considering all the technical difficulties in the way of the rapid popularization of electro-therapeutics, its recent progress is something unparalleled in the history of science: the dark days of its history are over, and they can never return.

That an agent which, by the almost unanimous consent of the profession, was resigned to outsiders and to those who were always ignorant and usually unscrupulous; which in text-books and lecture-rooms was mentioned only in tones of warning or disrespect; and which in this country, but a very few years since, was sunk so low that he who attempted to raise it was believed thereby to imperil his professional and social position—should, in so short a time, and against such inherent technical difficulties, assume a position side by side with its sister branches, where it should be taught in our schools, incorporated in text-books of general and special medicine, should occupy the attention of some of the ablest leaders of modern thought, and should arouse the enthusiasm of all ranks of the profession as no other special department has ever done, might well have seemed past belief, even to those who had the strongest faith in the liberality and activity of our time.

The beneficent results of this progress will not be confined to electro-therapeutics; they will react favorably on all departments, and especially on general therapeutics, by diffusing a wider liberality and a broader spirit of inductive investigation. The paths of all future explorers in the scientific treatment of disease will have been made easier and safer by the toils and the triumphs of this one department. Henceforth the cause will need not so much energy as guidance; not so much enthusiasm as wisdom.

We take this occasion to express our thanks to the very many able men in the profession who, in ways innumerable, and from the outset of our investigations, have so warmly co-operated in our labors, and whose intelligent sympathy and substantial encouragement for a cause that was yet on its trial in America, have largely contributed to whatever degree of success we have been enabled to achieve.

G. M. B. AND A. D. R.

40 EAST THIRTIETH STREET,
New York, Feb. 1, 1871.

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ELECTRO-PHYSICS.

ELECTRO-PHYSICS.

MAGNETISM.

ELECTRICITY is manifested in three forms—*Magnetism*, *Current Electricity*, and *Statical Electricity*.

Magnetism is the power which certain bodies possess of attracting iron. The bodies which are observed to have this power are called *magnets*, and are divided into two classes—*natural* and *artificial*. Natural magnets consist of iron ore or loadstone. Loadstone was first discovered in Magnesia, in Asia Minor, and hence the name *magnet* was derived. The compass was introduced into Europe in the 12th century; but the Chinese are said to have been acquainted with it in the 4th century.

Artificial magnets are usually made of steel that has been magnetized by the galvanic current, or by other magnets. Steel bars that have been thus magnetized may be either straight or bent. For convenience' sake, they are usually bent in the form of a horseshoe.

All substances are more or less susceptible to magnetic influence, but iron is more affected by it than others. Experiments illustrative of the effects and power of artificial magnets are so familiar that they need not be cited.

The *polarity* of a magnet is that peculiar property by which it manifests two opposite kinds of magnetism, that are termed, relatively to each other, the north and the south pole. When a magnetic needle is so suspended that it can move unimpeded in any direction, one end points to the north, and the other to the south. If the magnet be disturbed in any way, and forced temporarily out of position, it at once and uniformly returns.

The polarity of a magnet is also demonstrated when it is divided at its centre; for the halves become separate magnets, each having two poles, one pointing to the north, and the other to the south. We find, therefore, that it is impossible to insulate either pole in a magnet. One pole can only exist when it is associated with its corresponding opposite.

The poles of a magnet are always at its ends, for here the attractive power is greatest. This can be demonstrated by a very simple experiment. If a magnetic bar be rolled in a pile of iron-filings, it will be found that these adhere to the bar most firmly and in the greatest quantity at and near its poles. The quantity that adheres is less as we approach the middle of the bar. In long bars there is always a place at the middle, or near to it, where no filings are attracted. This space is variously termed the ***neutral*** or ***magnetic zone***, or ***magnetic equator***, or ***point of indifference.***

Another familiar experiment is to pass an iron ball, suspended by a string or thread, near to a magnet from end to end. It is observed that the ball is attracted very little, or not at all, in the middle, but that the attractive power is increased as we bring it towards either end. If any substance be placed between the ball and the magnet, the attraction is just as marked, unless the interposed substance itself contains iron. Nearly all substances that are not themselves magnetic are capable of transmitting the magnetic influence.

Another feature of magnetic polarity is, that like poles repel, and unlike poles attract, each other. If one magnetic bar be suspended freely in the air, and another be brought near to it, it will be found that the north pole of one is attracted by the south pole of the other, and *vice versâ*—in short, that the like poles repel, while the unlike attract.

Theory of Magnetism.—The wonders of magnetism have attracted the attention of some of the ablest physicists of the world, and have very naturally received a variety of interpretations. The theory which is the most familiar is, that the attractive power of a magnet comes from two magnetic fluids which it contains. These fluids are subtle and imponderable, like the light of the sun. One of the fluids is situated at the north (or +) pole, and the other at the south (or −) pole, and both receive their names accordingly.

The + fluid repels itself, but attracts the — fluid; and *vice versâ*, the – fluid repels itself, but attracts the + fluid. Both of these fluids are attractive of the matter of the magnet. In the unmagnetic state, those bodies which are capable of being made magnetic contain these two fluids in combination, and in equal amounts. This is the natural condition of bodies, and is called the ***magnetic equilibrium.*** This is confirmed by the fact that "two magnetic bars of equal size and intensity, when applied to one another in such a manner that ***heteronymous*** poles (poles turned in the same direction) are opposed, cease to exert any magnetic action."*

When a body which is capable of becoming magnetic is magnetized, these two fluids, which can exist in it in combination of equal quantities and in a neutral condition, are separated. "A more recent theory suggests that all substances capable of becoming magnetic consist of particles, each of which is a permanent magnet; that these infinitesimal magnets have their poles turned in all different directions, so as to neutralize each other when the whole is not magnetic; that magnetization has the effect of bringing the poles of these particles round so as to lie in the same direction; that this coincidence of poles, in the case of soft iron, takes place only when the iron is under induction; that in the case of steel it takes place permanently; and that the degree of magnetization is due to the completeness of the coincidence. This last way of conceiving of the composition of a magnet is both simple and satisfactory." † This theory is analogous to Du Bois-Reymond's molecular theory of animal electricity.

MAGNETIC INDUCTION.—If a bar of soft iron is brought in contact with or near to one of the poles of a magnet, it is attracted, and for the time being becomes itself magnetic; and if it is brought near enough to the magnet, it firmly adheres to it. A bar of soft iron thus obtains by *induction* all the properties of an ordinary magnet. It has a north and south pole. It attracts iron-filings around these poles, just like the regular magnet. If another piece of soft iron is brought in contact with, or near to its poles, it is attracted and made to adhere, just as it would do if applied to an ordinary magnet. Quite a number of bars of soft iron may be made to adhere in the same way. But when this bar, thus made magnetic, is forcibly removed from the permanent magnet to which it adheres, it instantaneously loses all its magnetic power, and the iron-filings or pieces of soft iron that have been attracted by it at once drop off. Such a magnet is therefore styled "*temporary*," in contradistinction to the *permanent* magnets of steel.

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* Electro-Physiology and Therapeutics. C. E. Morgan, New York, p. 3.

† Electricity Robert M. Ferguson. Ph D. 1862, p. 14.

If a bar of *steel* is brought near to, or in contact with a magnet, it also becomes magnetic, and exhibits very different phenomena from the bar of soft iron. In the first place, it becomes magnetic much more slowly than the bar of soft iron, and displays less magnetic power. On the other hand, it does not, like the soft iron bar, lose its attractive power as soon as it is removed from the magnet, but *permanently* retains it.

The quality of steel by which it at first resists the attractive power of magnets, and resists the dispersion of the magnetism which it has once acquired, is called *coercitive force.*

The same phenomena are observed in regard to heat. Some bodies that are quick to acquire heat, are quick to part with it; and *vice versâ*, those bodies which, like iron, steel, and so forth, acquire heat gradually, also part with it slowly.

It is by virtue of its coercitive force that *loadstone* permanently retains its magnetism.

The harder any steel is, the greater its coercitive force. Steel that is soft has comparatively little coercitiveness, and when brought near to, or in contact with a magnet, it behaves very much like soft iron. Very hard steel, on the contrary, has so great coercitiveness that it is only attracted by very powerful magnets.

Soft iron, when adulterated with sulphur, phosphorus, arsenic, or charcoal, or if it is even twisted or bent, may exhibit a slight degree of coercitive force. Soft iron that is perfectly pure possesses no coercitive force whatever.

SHAPE OF MAGNETS—MAGNETIC ARMATURES.—Artificial magnets are either composed of straight bars, or are bent in the shape of a horseshoe. The horseshoe form is used mainly for the sake of convenience. It enables us to apply both poles simultaneously and uniformly to the object that is to be magnetized. Very powerful magnets may be made of a number of thin steel bars placed side by side, their poles being situated homonymously, that is, lying in the same direction. A number of bundles of bars of steel arranged in this way is called a "*magnetic magazine*, or *battery*."

"*Magnetic armatures* are pieces of soft iron that are placed at the extremities of magnets, to preserve their magnetic power." This bar, or armature, not only receives magnetism from the magnet, but acts upon it in return, and thus helps to preserve its magnetic power. Magnets that are not provided with an armature gradually lose their attractive power by the disturbing influence of the magnetism of the earth. The magnetic power of magnets is apt to be impaired by letting them fall on a hard surface, or by suddenly striking them with a solid body.

MAGNETIZATION.—It is possible to communicate magnetism to bodies that can retain it in four different ways:

1. *By single Touch.*—The bar which we wish to magnetize is laid on a table, and the pole of a magnet is rubbed along its surface from end to end for a number of times.

2. *By double Touch.*—The bar that is to be magnetized is placed on a piece of wood, the ends of which are placed against two strong magnets. Two magnets for rubbing are placed on the bar to be magnetized, making an angle with the bar of from 15° to 20°. A small piece of wood is placed between the extremities of these two magnets, to prevent their touching. They are then rubbed along the bar that is to be magnetized, from the middle towards the end, and back again, and raised from the magnetized bar again at the middle. This method communicates a strong, though sometimes irregular magnetism.

3. *By the Galvanic Current.*—The bar to be magnetized is placed inside a coil of insulated wire through which a galvanic

current is running, and is then moved backward and forward, as in the method by the double touch.

4. *By the Earth.*—It is clear that the earth is itself a magnet, for it manifests strong inductive power. A steel rod becomes permanently magnetic when it is held parallel to a dipping-needle. If a bar of soft iron is held in the same position it also becomes magnetic, and much more rapidly than the steel bar, but does not so long retain its magnetism. If a soft iron bar, held in this position, is struck a few times by a hammer, its magnetism, which was before temporary, becomes permanent. The blows of the hammer seem to impart in some mysterious way a coercitive force to the temporary magnet.

Large masses of iron, when kept in a stationary position for any length of time, always give proofs of having been magnetized by the earth. Tools in workshops are apt to become permanently magnetic from the repeated hammering to which they are subjected. The magnetism of the loadstone is due to the silent but continuous inductive action of the earth.*

Saturation point of Magnetism.—The limit of the amount of magnetism that a magnet can permanently retain is called the *point of saturation.* If any magnet receives more of magnetism than it can permanently retain, it gradually loses it or throws it off until it falls to the point of saturation, when it ceases to lose any more. The saturative point of any magnet depends on its temper and coercitive force. Magnets will retain their magnetism at the point of saturation for years if they are not seriously disturbed.

Magnetism is very markedly influenced by temperature. When a magnet is heated it loses its magnetic power in proportion as its temperature rises; when it is cooled, it regains more or less of what it has lost. But if any magnet is subjected to a heating process for a number of times, it becomes less sensitive to the changes of temperature. All evidence of magnetism is driven out of a magnet at white heat, but it regains its capacity of magnetization after it has been tempered and magnetized.

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* Ferguson, op. cit., p. 2.

A H Cochran

TERRESTRIAL MAGNETISM.—When a needle is so placed that it can move freely in a horizontal direction, it always assumes a north and south position. When a needle is so placed that it can move freely in a vertical plane, it inclines more or less toward the earth.

These positions of a suspended needle are directed by the magnetism of the earth,—*terrestrial magnetism*,—and are respectively termed its *declination* and *inclination*.

Terrestrial magnetism is composed of three elements—*declination*, *inclination*, and *intensity*.

Declination.—The declination of the magnetic needle does not always coincide with the north and south points of the horizon, but as a rule only approximates to them.

The *magnetic meridian* is a vertical plane passing through the horizon at the points indicated by the needle.

The *astronomical meridian* is a vertical plane passing through the horizon at the north and south points. The angle between these meridians is called the *variation* of the needle.

Inclination, or *Dip*.—When the magnetic needle is free to move in a vertical direction, it inclines from the horizontal position. The angle between the needle thus inclined and the horizon is called the *dip* or *inclination*. This discovery was made by Robert Norman, an instrument-maker, of London, in 1576.

Intensity.—The magnetic force of the earth which brings the suspended needle to the magnetic position after it has been driven from it, is called intensity. "The needle may be looked upon as a magnetic pendulum, with magnetism instead of gravity as the force acting on it."*

Variations of the Needle.—The magnetic elements—inclination, declination, and intensity—vary at different places. These variations are called *secular*, *annual*, and *diurnal*.

Secular variations are those which take place in the lapse of centuries. In every place the magnetic elements vary with exceeding slowness from year to year, completing cycles of change in the course of ages.

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* Ferguson, op. cit., p. 17.

Annual variations are observed from month to month. The western declination, for instance, decreases between April and July, and increases during the remainder of the year.

Diurnal variations.—The needle has a mean daily position, from which it regularly deflects eastward or westward at certain hours of the day. At midnight the needle is 1½′ east of this mean daily position. It reaches its furthest east point at 8 o'clock in the morning. At one o'clock in the afternoon it reaches to 10′ west. It remains west of the mean until midnight. The needle is at the mean position a little after ten in the morning, and a little before seven in the evening. But the daily range of the needle varies in the different seasons of the year. In the month of May the average daily range between the eastern and western extremes is 12′. This is its maximum range for the year. In December the average daily range is 5′ 28″, which is the minimum for the year. Diurnal variations were discovered by Graham, an instrument-maker, of London, in 1722.

The diurnal variations of the range are not uniform in all parts of the world. Near the magnetic equator it amounts to very little or to nothing at all, but increases toward the north.

Occasional variations.—The daily course of the needle is liable to be quite materially altered by the various changes and disturbances of the earth and atmosphere. Sometimes these changes thus produced amount to one or two degrees. The singular fact has been established "that those on opposite sides of the globe, or differing by 180° of longitude, have disturbances equal in amount, but opposite in direction; and that those situated 90° west or east of the disturbed regions have little or no disturbance."*

It is very well known that the phenomena of the "northern lights" are accompanied by greater or less magnetic variations, even in countries where they are not seen. Earthquakes, volcanoes, thunder-storms, whirlwinds, and indeed all forms of disturbances and warring of the elements are liable to be associated with greater or less variations of the terrestrial magnetism. These disturbances have been termed by Humboldt "magnetic storms," and are known as such among telegraph operators and mariners.

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* Ferguson, op. cit., p. 37.

Theories of Terrestrial Magnetism.—To give in any details the various theories that have been presented to account for the phenomena exhibited by the magnetism of the earth would be both superfluous and unsatisfactory. It has been conjectured by some that magnetism is generated in the earth by the heat of the sun, and that the currents thus produced are continually traversing the surface. Others, again, have supposed that the whole earth was magnetic, and that it acted with its entire force at different points. The popular impression is, there is a magnet in the middle of the earth, extending between the two magnetic poles. It is evident that in the present state of science none of these theories can be either confirmed or disproved.

FRICTIONAL OR STATICAL ELECTRICITY.

When glass is rubbed with silk it acquires the power of *attracting* any light substance, such as a pith-ball. By a short contact this property is also communicated to the pith-ball, and it then *repels* the glass instead of being attracted.

These phenomena are explained by the existence of a force which is termed *Electricity*. That which exists in the glass is called *vitreous*, or *positive*, or + electricity. If a piece of sealing-wax be rubbed with flannel it will *attract* the pith-ball which is *repelled* by the glass. This phenomenon is due to the existence of *resinous*, or *negative*, or — electricity in the sealing-wax.

The name electricity is derived from the Greek word ἔλεκτρον, meaning *amber*, because, as the story goes, Thales of Miletus, one of the seven sages of Greece, first discovered the manifestations of this mysterious force by rubbing a piece of amber with a dry cloth. The science of electricity dates from 1600, when Dr. Gilbert, of Colchester, physician to Queen Elizabeth, published a work on magnetism, entitled *Tractatus de Magnete.* He first used the word *electricity*.

Not only sealing-wax and glass, but all bodies contain more or less of electricity that may be thus developed, by some kind of friction. All bodies are therefore electrically divided into three classes: conductors, semi-conductors, and non-conductors. Under the first class—conductors—are included water and all saline solutions, the metals, the earths and stones, the structures of plants and animals, etc., etc. Under the second class—semi-conductors—are included ether, alcohol, dry wood, marble, paper, straw, etc., at 32° F. Under the third class—non-conductors or insulators—are included glass, sealing-wax, porcelain, resins, sulphur, wax, dry metallic oxides, fatty oils, etc., at — 13° F.; phosphorus, india-rubber, gutta-percha, collodion, wool, dry hair, silk, shellac, ebonite, amber, feathers, chalk, lime, dry gases, and aqueous vapor in a dry state.

The conducting power of metals may be lessened by heating them. In nearly all other substances heat increases the conducting power. Certain substances, such as feathers, wool, hair, and the atmosphere, which in a dry state are non-conductors, become, when thoroughly moistened, the best of conductors.

In this classification of all substances into conductors, semi-conductors, and non-conductors, reference is had only to frictional electricity. Substances that are semi-conductors for frictional electricity are non-conductors for galvanic electricity.

Frictional electricity may be obtained not only by rubbing, but also by *cleavage* and *pressure*. When a piece of mica is cleaved, the two plates which are separated exhibit opposite electricities, and a faint light is observed when the cleavage is made in the dark. The light that is seen when sugar-candy or loaf-sugar is broken, is accounted for by the development of electricity through cleavage.

When a thin piece of cork is pressed against a slice of orange, by insulating handles, one assumes a positive and the other a negative electricity. The same phenomena may be obtained by cleavage and pressure of very many other substances, and under diverse conditions.

A conductor is said to be insulated when it is placed on some non-conducting substance, so that the electricity communicated to it is prevented from passing into the ground. Glass is one of the best non-conductors, and is the insulating material usually employed in the construction of electrical apparatus. It is hard, durable, and easily obtained, and, could its surface be kept always dry, would be surpassed as an insulator by no material. In frosty and dry weather it acts very well; but when the atmosphere is at all damp, it becomes coated with a layer of moisture, which very much impairs its insulating power.

A much superior insulator to glass is ebonite, a preparation of vulcanized india-rubber that of late has been much used. It is impossible, however, for any insulator to retain undiminished the charge of electricity which it may receive. The loss arises not only from the fact that the best of insulators are not perfect non-conductors, but because also the particles of air or dust become charged, and thus carry off the electricity. For this reason it is necessary, in all exact experiments, to ascertain how rapidly the charge diminishes, and, in estimating the results, to take it into account.

Statical Induction.—An electrified body always has a peculiar influence over the natural electricity of other bodies in its vicinity. This may be shown in the following manner: A brass cylinder (Fig. 1), rounded at either extremity, is insulated by means of a glass rod. Two pith-balls are suspended by cotton thread from each end. If an insulated ball charged with positive electricity be brought in close proximity to the brass cylinder, the pith-balls will diverge, showing a disturbance of the electrical equilibrium in the cylinder. So soon as the charged ball is withdrawn, the pith-balls hang down as before, showing that the electrical disturbance in the cylinder depended on the presence of the charged ball, and was merely temporary.

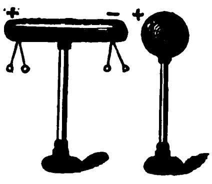

FIG. 1.

If a small disc of insulated gilt paper be brought in contact with the end of the cylinder next the charged ball, and then approached towards an electrometer, the needle will indicate that the disc has received — electricity.

If the experiment be tried with the opposite end, + electricity will be transmitted to the gilt disc.

It is thus seen that + electricity of the charged ball causes the near end of the cylinder to assume a — condition; while, according to a universal law, that no — electricity can be excited without an equal amount of positive electricity, the opposite extremity becomes +. The phenomenon thus described is called *induction;* and while in this peculiar electrical condition, the cylinder is said to be *polarized.*

Distribution of Electricity.—It is evident that the greater the surface over which electricity is diffused, the less is its power or intensity at any given point. If two bodies of equal size are insulated, and one of them is charged, the electricity will diffuse itself equally over the surfaces of both when they are brought in contact. It will be observed, however, that the electric tension of either body is but one-half of that of the body originally charged, thus showing that a large surface feebly charged is equivalent to a smaller one more highly electrified.

Electricity does not penetrate to the interior of metallic conductors, but diffuses itself over the surface.

Experiment proves this. Let a brass ball be charged with electricity, and suspended by a silk thread, and then covered with two hemispherical surfaces of brass, which exactly fit it. When the hemispheres are withdrawn it will be found that they are charged with the electricity, which has been entirely taken from the brass ball.

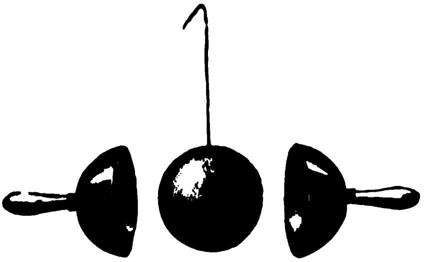

FIG. 2.

Faraday illustrated this truth by a beautiful and original experiment with a conical bag of cotton gauze, around the opening of which an insulated ring was attached. The bag was held distended by means of a silk thread attached to the apex, and then charged. By the proof plane, he found that the charge was wholly on the outside. The bag was then turned inside out by pulling the thread the other way, when it was found that the electricity had changed sides, and lay *wholly* on the outside. *Electricity concentrates on points and projections;* consequently its *distribution* is materially influenced by form. As a rule, an electrified ball exhibits the same tension on every part; but if a conductor is brought sufficiently near to the ball, the distribution is disturbed, so that the electric tension is greatest on the side nearest the conductor, and least on the side away from it. It is to this concentration of electricity on the side nearest the conductor that the electric spark is due. The nearer the conductor approaches, the more decided the disturbance becomes.

The Leyden jar illustrates very well the concentration of electricity on the thinnest dielectric. When a conductor of an oval shape is charged, it will be found that the electric tension is greatest at the two extremities and least in the centre; and as the extremities become more pointed and the centre more bulky, the difference is found to be all the greater.

Electric Machines.—This term is exceedingly vague. It is applied to any and all forms of electrical apparatus. The first electric machine was made in 1672, by Otto von Guericke,* of Magdeburg. It "consisted of a globe of sulphur turned by a handle, and rubbed by a cloth pressed by it by the hand." The common cylinder machine is the one that has been most familiar in the philosophical room, and at one time was considerably used in electro-therapeutics.

This is one of the forms of apparatus from which we obtain statical electricity. Fig. 3 represents the common cylinder electrical machine, for developing electricity by friction. A is a cylinder of glass, firmly supported, and capable of being turned on its axis by a handle, and E is a conductor supported on a pillar, having the rubber attached to it, with a flap of silk, K, extending nearly over the cylinder. G is made of sheet brass, and is called the prime conductor, because it receives the electricity from the cylinder as it is turned, by means of several pointed wires extending inwards towards the cylinder. It is supported upon a pillar of glass. Now, when the cylinder is turned, electricity is abundantly developed by the friction of the rubber against its surface, and is received by the prime conductor, in which it accumulates.

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* Experimenta Nova Magdeburdica.

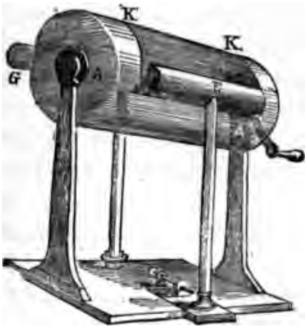

FIG. 3.

The use of the flap of silk, K, is to prevent the fluid from escaping in the air, as the cylinder is turned. When the machine operates properly, if the knuckle be presented near the prime conductor, a vivid spark passes between them, and a slight stinging sensation is felt; the same thing also takes place on presenting the knuckle to the rubber, provided it be insulated. In the first case, the effect is produced by accumulated positive electricity; in the second, by the negative.

Electrophorus.—An Electrophorus, invented by Volta, in 1775, consists of a metallic mould, filled with a mixture of shellac and turpentine, and a movable metallic cover, that is provided with a glass handle. The surface of the shellac is negatively electrified by beating it with a cat's fur, or fox-tail. The cover is then put on, and by contact becomes negatively electrified, and gives a slight spark to the finger of negative electricity. If the cover be now removed by its insulating handle, it gives positive electricity to whatever touches it. This positive electricity it acquires not directly from the shellac, but by *inductive action* through the air.

Holtz Electrophorus Machine.—The best and most recent form of apparatus for statical electricity is the electrophorus machine that was invented by Holtz,* of Berlin, in 1865. In this machine the electricity is generated not by friction, but, as in the electrophorus, by inductive action. The machine consists of two glass disks and paper coatings, with a number of conductors. One of the disks revolves on its axis; the other remains immovable. The disks and paper coatings are covered with sealing-wax.

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* A similar machine was constructed about the same time by Töpler.

The metallic conductors are made in a comb-shape. An incision in the immovable disk, with the paper coating and metallic conductor, is called an element. The machine may have two, four, six, or eight of these elements. When rotated the paper coating becomes charged with negative electricity: the corresponding part of the movable disk becomes charged with positive electricity. The conductor corresponds to the finger of the experimenter. The length of the spark produced by the machine depends on the size of the disk, which may be 12, 21, or 30 inches in diameter. These machines are also called *rotation multipliers*, because by their rotary motion they multiply by successive transmissions the charge of electricity that they communicate.

GOLD LEAF ELECTROSCOPE.—By this instrument we are enabled not only to detect the presence, but to determine the kind of electricity that may exist in any body.

Fig. 4 represents Bennett's electroscope. B is a tubulated glass

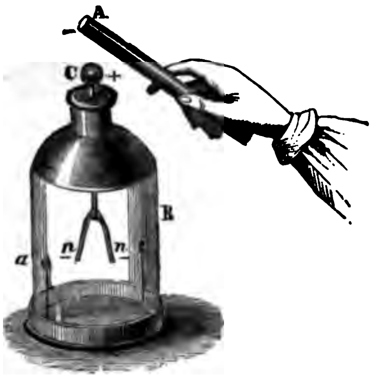

FIG. 4.

shade, enclosed at its lower end by a metallic cover, by means of which it communicates with the ground. A metal rod fitting in the tubulure of the shade, terminates at its upper extremity in a knob C, and at its lower extremity it holds two narrow strips of gold leaf. On the inside of the shade are two strips of gold leaf reaching to the metal cover.

If a body charged with either kind of electricity is brought in contact with the knob, the gold leaves diverge. "We may detect the kind of electricity in a given body by imparting to the electroscope electricity from the body under examination, and then bringing near it a rod charged with positive or negative electricity; or the electroscope may be charged with a new kind of electricity, and the electrified body in question brought near the electroscope."

LEYDEN JAR.—Electricity, which from peculiar inductive facilities, acts only in one direction, is called ***fixed***, ***bound***, or ***disguised electricity***. It is from the action of the Leyden jar that these

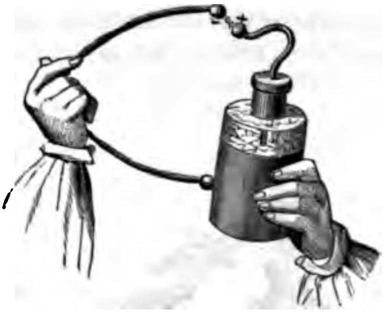

FIG. 5.

terms are derived. It is made of glass, with a coating of tin-foil pasted carefully inside and out, extending to within a few inches of the mouth.

Through a varnished wooden cover a wire, having a knob at top, is passed, and extends to the inside coating. Now, when either positive or negative electricity is communicated to the knob at the top, it is immediately diffused over the whole inside coating; and by its inductive influence the outside coating takes on the opposite kind.

When in this state,—the two coatings being oppositely electrified,—the jar is said to be charged; and a *discharge* takes place when a communication is established between the knob and the outside coating, the equilibrium being restored with a bright flash of light and a sharp report.

As the human system is a good conductor, this discharge may take place through it, by grasping the outside coating with one hand, and touching the knob at the top with the other; or several persons may form a line by grasping hands, the one at one extreme touching the outside coating, while the one at the other extreme touches the knob. All will feel the shock, as it is called, at the same instant. While the jar is receiving the charge, it must not be insulated; that is, the outside must communicate with the earth. As the positive fluid collects on the inside, the outside becomes negative by the expulsion of the positive fluid naturally in it, and the accumulation of the negative fluid in its stead, drawn from the earth. But if the outside is insulated, these transfers to and from it cannot take place, and therefore the jar cannot become charged. The Leyden jar was discovered in 1746, at Leyden, by Muschenbrock. The discovery has been contested by Cuneus, of Leyden, and Kleist, of Pomerania, in 1745. In the year following, Franklin studied the electric phenomena of the Leyden jar; and in 1752, by his experiment with a kite, established the identity of lightning and electricity.

CURRENT ELECTRICITY.

Current electricity is that branch of the science of electricity which treats of the electric currents arising, *first*, from chemical action, more particularly from that attending the dissolution of metals—called also *galvanism*, or *voltaic electricity*:—*secondly*, from the action of a magnet, called *magneto-electricity*:—*thirdly*, from heat—called *thermo-electricity*.

These varieties are also called dynamical electricity, signifying electricity in motion, and is thus distinguished from frictional or statical electricity, which denotes the electrical condition of bodies in which electricity remains insulated or stationary. Strictly speaking, these terms—dynamical and statical—are applicable to both branches of the science. If the poles of a series of galvanic batteries are insulated, they manifest, before the current begins, the electric tension of a friction machine.

Again, the characteristics of the galvanic current are manifested slightly in the series of discharges which are transmitted in a wire connecting the prime conductor of a machine in action with the ground or other negative conductor.

Galvanism.—In the year 1791, Galvani, professor of anatomy at Bologna, Italy, announced the discovery, which he had made five years previously, that muscular contractions were produced in the leg of a frog recently killed when two metals, such as zinc and silver, were applied, one to the crural nerve, the other to the muscles to which the nerve is distributed, and then brought in contact.

To this discovery we owe the science of galvanism.

Simple Galvanic Circles.—Three elements are necessary in the formation of a simple galvanic circle, of which two are usually metals, and the third some liquid.

Fig. 6 constitutes such a circle.

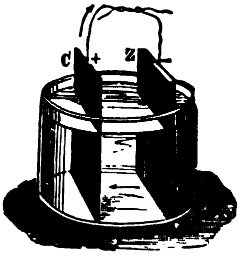

FIG. 6.

Let C and Z represent respectively plates of copper and zinc introduced into dilute acid, and connected by a wire. An electrical disturbance takes place over all the surface of the zinc covered by the liquid. Positive electricity is generated at the zinc element, and flows through the liquid to the copper, and thus a constant current is established over the wires, as shown by the arrows.

So far as the galvanic action is concerned it matters not whether the plates touch each other, or are connected by wires, as in the figure. A current is formed, whether contact is made between the plates either above or below the liquid. In every instance, however, a *circuit* must be formed, around which the electricity may flow.

The stream may traverse the circuit either in a single current or in a number of partial currents, into which it may divide itself when the plates are brought in contact along their whole surfaces. When the plates, or the wires which connect them, are in contact, the circuit is said to be *closed;* when they are separated, it is said to be *broken* or *open.* The electricity is generated wholly by the chemical action of the acid upon the zinc, and, other things being equal, the quantity of electricity set in motion will be proportional to the extent of zinc surface exposed to the acid. Both in simple and compound circles the electricity always moves in the liquid of the battery from the zinc to the copper; and out of the liquid, from the copper to the zinc. This should be remembered, since the zinc is called the electro-positive element, although out of the liquid it is negative; and, consequently, in the decomposition that occurs in the battery, that element which goes to the zinc pole is called the electro-positive element, being attracted by its opposite force; while the element going to the copper is called, for the same reason, the electro-negative. Two liquids and one metal can also produce a circuit as well as one liquid and two metals. Becquerel's oxygen battery (pile à oxygène) is one of the best arrangements of this kind. The current is produced by the action of caustic potash on nitric acid, platinum forming the conducting arc.

Homogeneity of the Circuit.—In frictional electricity there are points which form the seat of + or — electricity. On the contrary, in a wire where a galvanic current is circulating, there are no such points. It appears to be electrically homogeneous throughout. It may be handled, and it feels in no way different when a current is passing and when it is not. The galvanic current has no power, like statical electricity, to repel and attract light objects. It possesses the same amount of force at every point, and its magnetic, chemical, and heating effects are the same wherever tested in the wire.

Electrical Relations of the Elements.—In the galvanic cell, by the decomposition of the water, oxygen arises at the positive pole, and hydrogen at the negative. Now, not only the metals, but also these elements (oxygen and hydrogen), assume opposite electricities. The zinc is +, as is also the oxygen which it liberates. The copper is —, and so is the hydrogen which it liberates. The elements have been arranged as to their electro-chemical relations when associated in pairs in the galvanic cell. Some of the most common are here arranged. We begin with the most electro-positive, and end with the least positive, or negative.

Potassium.
Sodium.
Magnesium.
Zinc.
Iron.
Aluminum.
Lead.
Tin.
Bismuth.
Copper.
Silver.
Mercury.
Platinum.
Gold.
Hydrogen.
Antimony.
Carbon.
Phosphorus.
Iodine.
Chlorine.
Nitrogen.
Sulphur.
Oxygen.

Thus, for example, copper, when associated in a galvanic pair in the proper fluid, with any one of the elements below it, generates positive electricity and becomes electro-positive, but when associated with any one of the elements above it, becomes electro-negative.

The more electro-negative any one of the elements in this series is to a given element, the more intense will be the current generated when they are united in a galvanic pair. For example, the current generated by zinc and copper is less in intensity than that obtained from zinc and platinum, and still less when carbon is substituted for the platinum. The order in the above arrangement is, however, by no means absolute.

The relative position of the metals depends frequently on the liquid in which they are immersed. Thus silver is — towards lead in a solution of dilute sulphuric acid, while in a solution of cyanide of potassium it is + towards it.

Local Action.—Sir Humphrey Davy discovered that a plate of zinc, when attached to the copper sheathing of ships, below the water, protected 150 times its own surface.

Iron is readily affected by hydrochloric acid ; but if a piece of zinc be put into the acid, and made to touch the iron, the latter will remain unaffected until the zinc has first been dissolved. By this it is seen that whenever iron or copper is exposed to corrosive action they may be protected from it by coupling them with zinc.

On the contrary, when zinc is coupled with a metal that is negative to it, it readily corrodes; hence, whenever zinc is used in connection with any other metal, as in the construction of a zinc roof, it is necessary to use zinc nails, instead of iron or copper ones. We see by these illustrations, and by reference to the table, that the electro-negative metal remains wholly unaffected when placed with the electro-positive in some exciting liquids.

Amalgamation.—If pure zinc is immersed in dilute sulphuric acid no change is manifest, while ordinary commercial zinc is quickly dissolved by it.

Now, local action in a single battery cell, arising from the above cause, not only consumes the power of that member, but reduces the energy of the whole series. In order to avoid this evil resulting from local action, it is necessary that the zinc plates be amalgamated with mercury.

The amalgamated surfaces are reduced to one uniform electrical condition, and will remain in the fluid for any length of time unacted on, until connected with the electro-negative element.

At the present time all improved batteries are constructed with amalgamated zinc. Amalgamated zinc was first used for galvanic batteries by Kemp, in 1826.

Theoretical Views.—In order to explain the ordinary phenomena of electricity generated by *friction*, two theories were at first proposed. Dr. Benjamin Franklin proposed the first, which is called the Franklinian hypothesis. It supposes that there is a simple, highly elastic, and subtile fluid, that is self-repellent, and that pervades and attracts all matter. While in their natural state, bodies have this fluid equally distributed over them, but when a substance, such as a glass tube, is rubbed with a piece of silk, the electrical equilibrium is disturbed. The glass becomes charged with more than the natural amount of electricity, while the silk becomes undercharged.

Du Fay proposed the second theory. He supposed that two highly elastic imponderable fluids (the particles of which are self-repellent, but attractive of each other) existed in all unexcited bodies, in a state of combination and neutralization.

Du Fay's theory supposes that in the simple experiment with the glass and silk the electric fluids become separated, and the electrical excitement in the glass continues until an equal amount of opposite electricity to that excited has been restored to it. In most cases, when glass or other vitreous substances is rubbed, the electricity which they acquire is the opposite of that obtained when sealing-wax is subjected to friction; hence the former is called vitreous or positive, and the latter resinous or negative electricity.

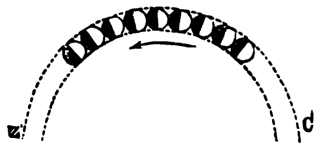

FIG. 7.

Faraday, in his theory of electric action by induction, assumes that electricity may be nothing more than a molecular property of matter, and thus seems to overturn the other theories.

"According to the views taken of the propagation of electric force by molecular action, we may consider the molecules of the interpolar wire to be shown in Fig. 7, C being the copper end, and Z the zinc end, the shaded part being + and the unshaded —. The first effort of the electric force developed by the chemical affinity of the zinc for the O or SO_4 is to throw all the molecules of the circuit into a polar condition, the force being transmitted from molecule to molecule in both directions. + and — electricities appear in each molecule of the circuit; and if the action be powerful enough, discharge takes place throughout the whole, each molecule giving out its electricities to those next it, which, throwing out the opposite electricities, produce electric quiescence throughout. A constant series of such polarizations and discharges constitutes a current. There is thus only a transmission of force throughout the circuit, but no transmission of the + and — electricities. *Each molecule, in fact, may be looked upon as a small galvanic pair*, which, by the action of electric force, is made to act and discharge somewhat like the galvanic pair which is the seat of the force.

"Accordingly, whatever portion of the circuit without the liquid we take, such as that in the figure, we find the face of the terminal molecule next the copper end or pole —, and that of the like molecule towards the zinc +. Each portion of the circuit, like each molecule of which it is made up, shows opposite polarities, and discharges opposite electricities at each end.

"The same holds within the liquid, only the chemical affinity that gives rise to the current and the mobility of its molecules, causes and permits an interchange of molecules; just as if each half of the molecules in Fig. 7 were at each discharge joined to the succeeding one.

"This interchange is not possible, even were there a tendency to it in the solid part of the circuit."*

Compound Galvanic Circles.—The compound galvanic circle or galvanic battery is composed of two or more simple galvanic circles. They are so connected together that the copper of one battery is joined to the zinc of the next, and so on throughout the series. By combining together a number of cups, such as are represented in Fig. 8, we form an excellent compound circuit. Each cup contains a zinc and a copper plate, which are connected together as described above. By examining this arrangement it will be seen that one extreme of the series is copper and the other zinc. If these two extremes or poles are connected by a copper wire, the current will flow in the direction of the arrows, both through the series and over the wires.

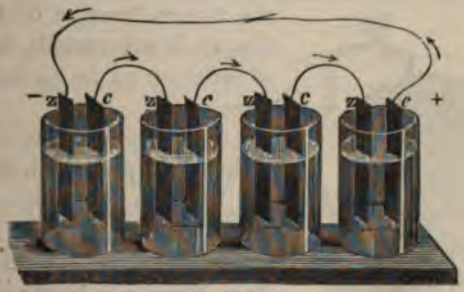

FIG. 8.

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* Ferguson, op. cit., p. 118.

GALVANIC BATTERIES.

Under this head may properly be included first a description of the *voltaic pile*, which was constructed by Volta in 1799, and became known in England in 1800. The apparatus consists of a number of discs piled one above the other. The arrangement is in the following order: A disc of copper is placed on a frame of wood; a disc of cloth, moistened by acidulated water, is then placed on the copper, and then a disc of zinc on the cloth completes what is called the voltaic couple. A series of such couples constitutes a voltaic pile—the terminal copper being the positive, and the terminal zinc the negative pole.

This apparatus is inconstant and unreliable, easily corrodes, has many inconveniences, and is now but little used. *Wollaston's battery* and *Hare's deflagrator* are improved modifications of the voltaic pile. Even the latest modifications are too inconstant for electro-therapeutical purposes.

Constant Currents.—What are commonly called constant currents are generated from batteries composed of elements with two liquids. The current produced by elements with a single liquid becomes more rapidly enfeebled than the former, because of the polarization, or, in other words, the deposition of hydrogen on the surface of the negative metal.

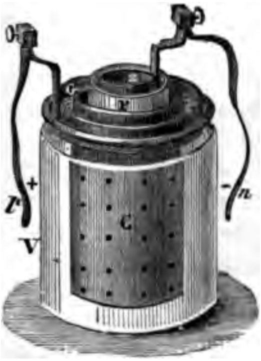

FIG. 9.

This polarization or deposition of hydrogen is prevented, in the following batteries of Daniell, Grove, and Bunsen, by placing the electro-negative element in a liquid that is acted upon chemically by the deposited hydrogen.

Daniell's Battery.—Fig. 9 represents a single cell. V is a glass or porcelain vessel nearly filled with a saturated solution of sulphate of copper. C is a cylinder of copper, open at both ends and perforated by a number of holes. G, which is also perforated by holes, is an annular shelf at the upper portion of the zinc cylinder, upon which crystals of sulphate of copper may be placed, to supply the waste in the cell caused by the electrical action.

P is a thin porous vessel of unglazed earthenware, containing the amalgamated cylinder of zinc Z, and a solution either of common salt or dilute sulphuric acid. The elements are connected in series by strips of copper, *p* and *n*, which are fixed to the copper and zinc by means of binding-screws. When the circuit in the battery just described is closed, the action of the acid on the zinc produces hydrogen, which is liberated on the surface of the copper cylinder. Its action here is to reduce the sulphate of copper which it meets, forming sulphuric acid and metallic copper.

The metallic copper thus formed is deposited on the copper vessel, while the sulphuric acid permeates the porous cylinder and so replaces the acid used up by its action on the zinc. Since the union of the hydrogen with the sulphate of copper forms a regular quantity of sulphuric acid, and in proportion to the decomposition of the acid in the porous cylinder, the action of the acid on the zinc here is also regular, and a constant current is necessarily the result.

The current obtained from this battery will flow with undiminished strength for hours, and, in fact, is superior to all its fellows in constancy. Daniell's battery was invented in 1836.

Grove's Battery.—This battery differs from Daniell's mainly in the substitution of a nitric acid for a sulphate of copper solution, and platinum for copper, by which increased electro-motive force is obtained. In Fig. 10, A represents a glass vessel containing dilute sulphuric acid, Z a cylinder of zinc open at both ends, and V a porous pipeclay vessel partially filled with nitric acid. P is a plate of platinum, with a cover, C, which rests on the porous vessel when the platinum is immersed in the nitric acid solution; *b* and *a* are binding-screws which connect respectively with the platinum and zinc.

In this arrangement, hyponitrous acid is formed by the union of the hydrogen with the nitric acid, and is either dissolved or disengaged as nitrous fumes. In this way the hydrogen is prevented from adhering to the platinum plate, and so interfering with the intensity of the current. Grove's battery was invented in 1839.

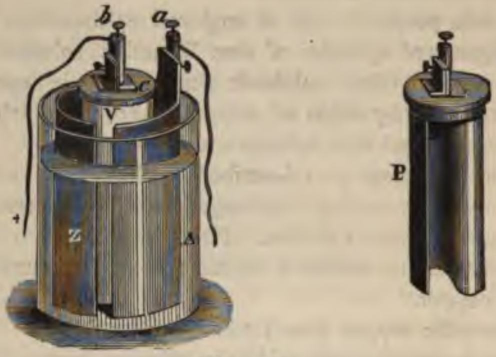

FIG. 10.

Bunsen's Battery.—This battery is very similar to Grove's. It differs from it only in the substitution of carbon for platinum. The letter P in Fig. 11 represents a single element, as it appears when ready for use.

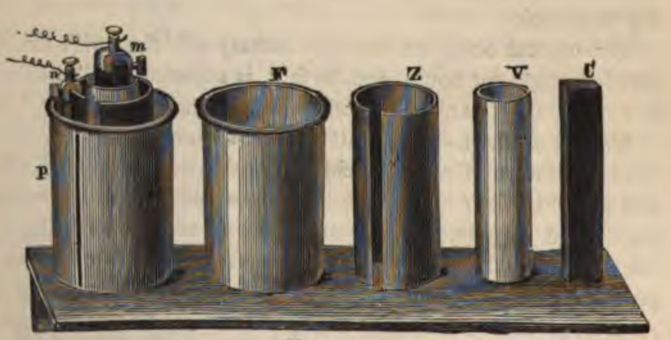

FIG. 11.

F is a vessel of glass containing dilute sulphuric acid. Z, a cylinder of amalgamated zinc. V, a porous vessel partly filled with ordinary nitric acid; and C, a bar of carbon or coke. The zinc is first placed in the vessel F, after which the porous vessel

V, into the nitric acid solution of which the carbon C has been immersed, is inserted into the zinc cylinder. The binding-screws *m* and *n* are respectively the positive and negative poles. The elements are arranged in the form of a compound battery, by means of the clamp *m*, *n*, and a rod connecting the carbon of one cell with the zinc of the following.

In our own practice with this battery, we have substituted the following solution for the nitric acid:—

Bichromate of potash	℥ j.
Sulphuric acid	f ℥ ij.
Water	℥ xvj.

Mix.

While the action of Bunsen's battery is the most energetic of all the constant batteries, and while the first cost is less than Grove's, it is yet more expensive to work and more inconvenient to manipulate. Bunsen's battery was invented in 1843.

Smee's Battery.[*]—This arrangement is not only economical and convenient, but is also very clean. Each element consists of a plate of platinum between two plates of zinc. It cannot really be called a constant battery, since only one liquid (sulphuric acid) is used. As in the batteries just described, hydrogen is prevented from adhering to the negative plate. This is accomplished by sprinkling over the platinum a quantity of finely-divided platinum. This lessens the resistance of the battery, by facilitating the disengagement of the hydrogen. Smee's battery was invented in 1840.

The electro-motive force of these batteries is relatively as follows:—

Bunsen's element	839
Grove's "	829
Daniell's "	470
Smee's "	210

Quantity and Tension of the Electric Current.—The *quantity* of electricity generated by any apparatus is proportioned to the amount of chemical action that takes place in the battery. *Intensity*, or *tension*, is that power that enables it to overcome resistances that may impede the progress of the current. The electricity of a thunder-storm is great in intensity, but exceedingly small in quantity. On the contrary, that which is generated by any ordinary form of battery has comparatively a great deal of quantity, but little intensity. It has been estimated by Faraday, that if a wire of zinc and one of platinum, $\frac{1}{18}$ of an inch thick, be immersed $\frac{5}{8}$ of an inch in a solution of one drop of sulphuric acid to four ounces of water, they will produce, in three seconds, as great a quantity of electricity as thirty turns of a fifty-inch plate machine. The *quantity* supplied by any battery may be increased by increasing the chemical action that takes place in it, either by making it larger or by strengthening the acid solution. The actual quantity of electricity flowing over the wires which connect the *poles*, or *electrodes* of a compound battery is no greater than the amount generated during the same time in a single cell of the battery.

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[*] A cut of this battery is given in the description of Kidder's apparatus.

The action of the liquid upon the surfaces of the zincs causes the same electrical disturbance in each cell. The liquid becomes positive, while the zinc above the liquid becomes negative. The positive electricity of the liquid is conducted through the copper plate to the negative zinc of the next cup, where it becomes exactly neutralized. While the *quantity* of electricity of a compound battery is not increased, however extensive the series may be, it will be found that its intensity is very much greater than can be obtained from a single cell. The current from a single pair of plates, however large they may be, is exceedingly feeble, and will not flow unless the polar wires are brought in contact. In a compound circuit, if the series be sufficiently extensive, the connecting wires may be separated a little distance, and the current will continue to pass between them with a brilliant flame.

The relative meaning of these terms, *quantity* and *intensity*, may be best understood by an illustration. A gallon of water, heated to 100°, has a much greater quantity of heat than a pint heated to 500° ; but the heat of the latter is much more intense.

An *electro-motor* is the cell or battery that generates the current.

The *quantity* or *strength* of the electric current is proportioned to the amount of chemical action, or " the quantity of zinc dissolved in a given time." It is estimated in three different ways.

1st. By the temperature to which it raises a wire of given thickness and material. 2d. By its power to deflect the magnetic needle. 3d. By the chemical decomposition it effects.

The *electro-motive force* is "the power to keep electricity in motion, and to maintain a current against resistance." This force may be measured by means of a condensing electrometer.

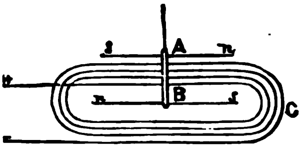

FIG. 12.

Before the circuit of a battery is closed, the — pole should be connected with the ground, and the + pole with the electrometer.

The attraction or repulsion of the gold leaves will indicate the electro-motive force of the current. *Resistance* is that which prevents the electro-motive force from developing the strength of the current.

Astatic Galvanometer.—The galvanometer is used either to discover the existence of a current, or to measure the strength of a weak current. Let A and B, Fig. 12, represent two needles of about equal strength, having the same axis, and having their poles reversed in reference to each other. The needles will settle a very little in the meridian, from the fact that one of them is very slightly more highly magnetized than the other.

C is an insulated wire, bent around the lower needle several times. When a current is passed through this wire, the needles will be influenced to turn in the same direction. In this way the passage of the most feeble current may be detected. In connection with a thermo-electric pile, this instrument is capable of indicating a change of temperature of only a very small fraction of a degree.

Ohm's Law.—This law assumes that the electro-motive force for any galvanic pair is constant, and that the quotient which results from dividing this force by the resistance of the circuit, equals the strength of the current produced by the pair. To estimate the effective force, then, of any simple galvanic arrangement, it is necessary to consider three things:—1st. The tension of the electric fluid, or the electro-motive force; 2d, the resistance occasioned by the wires connecting the poles; 3d, the resistance due to the liquid within the battery.

Let the absolute tension be represented by t, while l represents the resistance of the liquid within the battery, and r the resistance of the wire connecting the two poles. Let A represent the effective force. Naturally, then, $A = \frac{t}{l + r}$. By this formula we see that the effective power of the battery will be proportional to the absolute tension of the current, and inversely as the sum of the resistance of the liquid within the cell and that of the interpolar wire.

In applying this same law to a compound series, supposing n to represent the whole number of cells, we have the formula: $A = \frac{nt}{nl + r}$. The effective power, then, is proportional to the electro-motive force of each cell multiplied by the number of cells, and inversely as the resistance of the interpolar wire and the liquid of the cells. The resistance of the wire will depend upon its length, and inversely on its thickness or diameter. The resistance offered by the liquid will be proportional to its quantity, and inversely as its conducting power.

ELECTRO-MAGNETISM.—In the year 1820, the law of electromagnetic attraction and repulsion was first made known by Prof. Oersted, of Copenhagen.

Ampère's Theory of Magnetism.—Soon after this discovery of Oersted, M. Ampère, of Paris, advanced the idea that a series of electrical currents circulated about the earth from east to west, nearly at right angles to its magnetic axis. By thermo-electricity (generated by the rays of the sun falling upon the surface of the earth and encircling it with a series of spiral lines) he proposed to account for the phenomena of magnetic induction and of terrestrial magnetism. According to Ampère, each particle of a magnet has currents circulating about it in the same direction; but all these currents may be regarded as equivalent to a single strong current that circulates round the magnet as a whole. Before iron or steel, for example, is magnetized, these currents run in different directions, so that their effect as a system is lost.

Induction causes them to run in the same direction; and when magnetization is perfect, the various currents run parallel to each other. Steel offers great resistance to this disposition of the currents in parallel lines, while soft iron offers no such resistance.

Helix.—Magnetism is induced in a bar of soft iron by the simple passage of a current near it, in a direction at right angles to the bar. If, however, the wire (Fig. 13) encircles the iron many times, this effect will be much increased. Let a current be passed over the wire in the direction of the arrows, and the iron within will become strongly magnetic, with its poles as shown by the letters S and N. If the enclosed iron be not too heavy, it will be drawn to the centre and held suspended there.

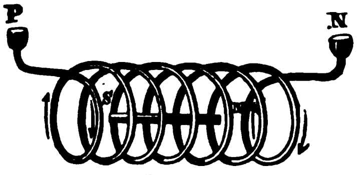

FIG. 13.

When the current is broken, the iron ceases to be magnetic; while, if a bar of hardened steel be substituted for the iron, it will retain its magnetism permanently. Such a coil of wire is called a helix, and a magnet formed in the manner described is termed an *electro-magnet.* Fig. 14 represents the general form of an electro-magnet.

It is composed of a bar of soft iron, bent into the form of a horseshoe. An insulated wire is coiled round its extremities. When a current of electricity is passed through the coil, the horseshoe bar becomes magnetic, and attracts the armature. If the current is broken, the bar becomes demagnetized and the armature falls to the ground. Permanent magnets possess much less power than electro-magnets.

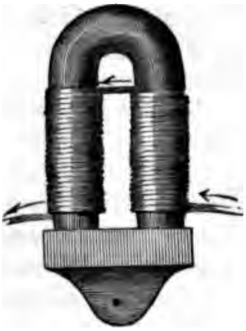
FIG. 14.

If the iron bar within the helix be more than a third of an inch in thickness, and the current be of moderate strength, the magnetism induced is in proportion to the strength of the current, and of the number of turns in the coil. Additional coils of the wire give no increased magnetism, if the bar is thinner than one-third of an inch. In this case maximum is soon reached. Again, if the circuit is made very long, thus reducing the strength of the current, the advantage usually gained by the thick bar, and by increasing the number of coils, may be lost. The iron bar should be perfectly pure and well annealed, in order that the electro-magnet may quickly acquire and as quickly lose its magnetism on closing and breaking the circuit.

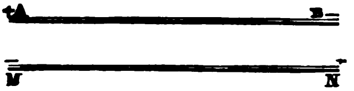

FIG. 15.

CURRENT INDUCTION.—If a current of electricity is passed through any conductor, it will induce a current in the opposite direction in a second conductor situated parallel to the first. Let A B be a wire connected at either extremity with the poles of a galvanic battery, and M N a second wire parallel and near to the first. As soon as the circuit is formed, and a current passes from + to —, a secondary current is induced in the second wire, but in an opposite direction.

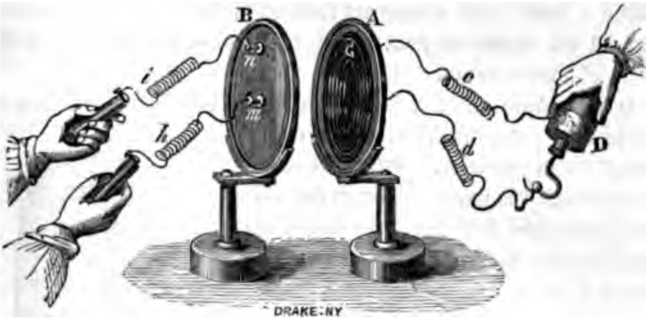

FIG. 16.

This current is, however, but for an instant. As soon as the circuit is broken, an instantaneous current, with its direction reversed, is again established in the second wire.

Fig. 16 "represents an apparatus devised by Matteucci, which is very well adapted for showing the development of induced currents, produced either by the discharge of a Leyden jar or by the passage of a voltaic current. It consists of two glass plates, about 12 inches in diameter, fixed vertically on the two supports A and B. These supports are on movable feet, and can either be approached or removed at will. On the anterior face of the plate A are coiled about 30 yards of copper wire, C, a millimetre in diameter. The two ends of this wire pass through the plate, one in the centre, the other near the edge, terminating in two binding-screws, like those represented in *m* and *n* on the plate B. To these binding-screws are attached two copper wires, *c* and *d*, through which the induced current is passed.

" On the face of the plate B which is towards A is enrolled a spiral of much finer copper wire than the wire C. Its extremities terminate in the binding-screws *m* and *n*, on which are fixed two wires, *h* and *i*, intended to transmit the induced current. The two wires on the plates are not only covered with silk, but each circuit is insulated from the next one by a thick layer of shellac varnish, a condition necessary in experimenting with statical electricity, which is always more difficult to insulate than that of the voltaic current, in consequence of its greater tension. In order to show the production of the induced current by the discharge of a Leyden jar, one end of the wire C is connected with the outer coating, and the other end with the knob of the Leyden jar as shown in the figure. When the spark passes, the electricity traversing the wire C acts by induction on the neutral fluid of the wire on the plate B, and produces an instantaneous current in this wire. A person holding two copper handles connected with the wires *i* and *h* receives a shock, the intensity of which is greater in proportion as the plates A and B are nearer.

" This experiment proves that frictional electricity can give rise to induced currents as well as voltaic electricity. The above apparatus can also be used to show the production of induced currents by the influence of voltaic currents. For this purpose the current of a battery is passed through the inducing wire C, while the ends of the other wire *h* and *i* are connected with a galvanometer. At the moment at which the current commences or finishes, or when the distance of the two conductors is varied," * secondary currents are manifested in the wires *i* and *h*.

As the secondary current flows in a direction opposite to that of the battery current, so the *tertiary* flows in a direction opposite to the secondary. This law holds good throughout the whole series,—the strength of the current diminishing as the distance from the battery increases.

The manifestation of electrical action in the secondary coil, upon closing and breaking the circuit, is called the electric throb, while the passive condition of the wire while under induction has been described by Faraday as electro-tonic.

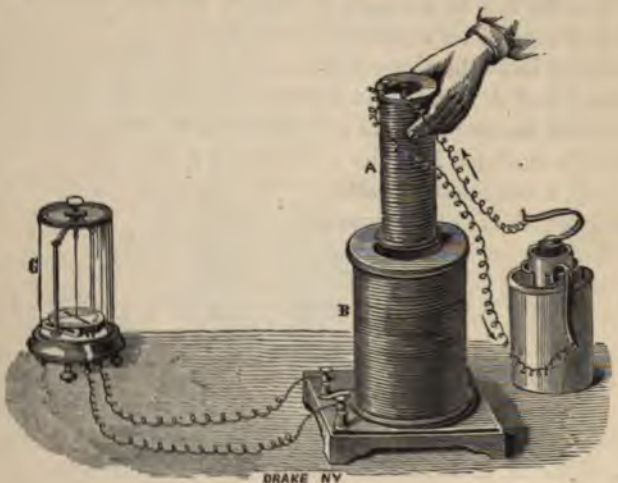

FIG. 17.

If the primary coil be movable, so that it can be brought in closer proximity to the secondary coil while the current is passing, an inverse current is produced at the moment of its approach the same as when the circuit is closed. If now the primary coil be withdrawn, a direct current is produced, the same as when the circuit is broken. As long as the primary coil remains in one position, all evidence of electricity in the secondary wire disappears. If, however, while in this position, the strength of the primary current be increased or diminished, momentary currents are established in the secondary coil; the inverse following the increase, and the direct current following the decrease in the strength of the primary current. From these facts we conclude that "*a current which begins, a current which approaches, or a current which increases in strength, induces an inverse momentary current in a neighboring conducting circuit, and that a current which stops, a current which retires, or a current which decreases in strength, induces a direct momentary current in a neighboring circuit.*" * In thus experimenting, it is much more convenient to wind the wires on separate bobbins, so that one may be placed within the other, as represented in Fig. 17.

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* Ganot's Physics, Am. Ed., p. 741.

Let A represent the primary coil, which is composed of wool-covered wire, $\frac{1}{18}$ of an inch in diameter; and B, the secondary coil, of silk-covered wire, much longer than the other, and about $\frac{1}{80}$ of an inch in diameter. Now let the secondary coil be connected with the galvanometer, G, by means of the two binding-screws, while the primary coil, by two loose and flexible wires, is placed in the circuit of a galvanic cell. As soon as A is inserted into B, a momentary inverse current is indicated. If it be withdrawn, the galvanometer indicates a momentary direct current. While the primary coil remains in the secondary, the needle announces the induction of currents according to the principles stated above, whenever the strength of the primary current is increased or diminished.

Extra-Current.—The extra-current is that which is induced by the current in each coil or winding on the other adjacent coils.

The coils act inductively on each other both at the opening and the closing of the circuit.

The electro-motive force of the extra-current bears a uniform relation to the intensity of the primary or inducing current.

Rheotome, or Current Break.—The rheotome is a contrivance for completing and breaking the primary current. This arrangement is necessary in order to obtain any very great effect from the secondary coil. It is to be placed in the circuit of the primary coil, in order to effect the interruptions of the current essential to its inductive action.

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* Ferguson, op. cit., p. 184.

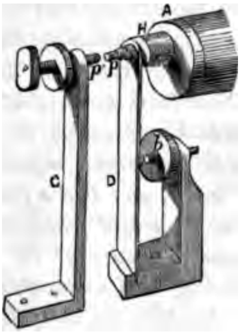

Fig. 18.

Fig. 18 represents a rheotome. "A is an iron plate into which the ends of the iron wires forming the core are fixed, and which serves as an anvil for the hammer H. H has for its shaft the stiff spring D, which keeps *p* back, and also forms part of the primary circuit. *p* is a little projecting nipple, tipped with platinum. *e* is a screw, the end, *p'*, of which is also tipped with platinum. C, an upright brass standard, also forms part of the circuit. When the circuit is closed, A becomes magnetic, and draws away H from *p'*. The primary circuit formerly closed at *p*, and *p'* is now broken. A loses its magnetism, and H, under the influence of the spring D, is taken back to *p*. The circuit is again closed, A again becomes magnetic, and thus H is kept oscillating with great rapidity between A and *p'*, alternately opening and closing the primary circuit. *b* is a screw, giving to D the necessary stiffness." *

Iron Core of Primary Coil.—The inductive power of the primary current is very greatly increased by putting a bar of soft iron or a bundle of iron wires in the heart of the primary coil.

A bundle of wires is preferable to a single bar of soft iron, for in the latter, currents are formed which impede the sudden cessation of the primary current, while in the former, these cannot be formed. It is necessary that the primary current should be strong, since its principal object is to excite magnetism in the core, consequently the coil is made of thick wire and of moderate length. The secondary coil, however, is made of very thin wire, and of great length, so that as many turns as possible may be brought within the influence of the core and of the primary coil, and thus produce a secondary current of intensity. As with the galvanic or primary current, the electro-motive force of the battery is proportionate to the number of cells; so with the induced or secondary current, the electro-motive force of the coil is proportionate to the number of turns in it.

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* Ferguson, op. cit., p. 189.

Quantity and Tension.—By means of the galvanometer, the relative quantity and tension of the inverse and direct secondary current may be measured. Thus, if a galvanometer be connected with a secondary coil, while the current of an enclosed primary coil is effected by the rheotome with great rapidity, the induced inverse and direct currents are sent with corresponding rapidity through the coil of the galvanometer. If this last coil be made of thick and short wire, so that the tension of the current be not taxed, it will not be deflected. Hence, "the quantity of electricity transmitted by the induced inverse and direct currents is the same, since they exert the same influence on the needle." If the coil of the galvanometer be of a long and fine wire, it will be deflected in a direction that shows the action of the direct current. Hence we conclude "that both currents, though equal in quantity, are unequal in tension, the direct current having the highest tension, for it has more power to force its way through the fine wire of the galvanometer than the inverse." The discovery of current induction was published by Faraday, in 1831–1832.

The first electro-magnetic machine used in medicine was made by Neef & Wagner. Improvements and modifications have since been made by Stöhrer, Du Bois-Reymond, Duchenne, Siemens, and Halske, Legendre, Ruhmkorff, and Hall, Kidder, and others.

Magneto-Electricity—Magneto-Electric Induction.—As may be inferred from the term, magneto-electricity is the reverse of electro-magnetism.

We have seen that when a coil in which a primary current circulates is inserted within a larger one, a momentary inverse induced current becomes manifest in the outer coil. When it is withdrawn, the act excites an instantaneous *direct* induced current. *A priori*, if for this coil with the primary current we substitute a permanent steel magnet and place it within the large coil, it would seem probable that a current of electricity would be developed. Experiment shows this to be true; although the current is observed only at the moment of the insertion and withdrawal of the magnet. The development of magneto-electricity is shown in a very simple manner by the common horseshoe magnet, its armature, and a copper wire. Let the armature A B be encircled by the wire C, one end of which is flattened and amalgamated with nitrate of mercury, and the other filed to a point. When the armature is placed upon the magnet, the moment of contact, when it is withdrawn, and the act of withdrawal will each be marked by a spark of electricity at C, where the two extremities of the wire meet.

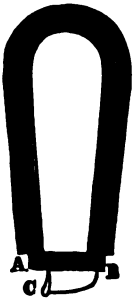

FIG. 19.

The electric current flows in one direction at the instant magnetism is induced in the soft iron which is enclosed by the coil of wire, and in the opposite direction when its magnetism is destroyed. Magnetism of Rotation was discovered by Arago in 1824–25. The first magneto-electric machine was made by Faraday, in 1831. The first machine of the style now used was made by Pixii, in 1832. Improvements have been since made by Saxton (1833), Clarke (1836), Petrine (1844), Stöhrer (1844), Siemens, Halske, Duchenne, and others.

Thermo-Electricity.—By heating the junction of two heterogeneous conductors a current of thermo-electricity is obtained. The two most important methods of generating thermal currents are: 1st, with two portions of the same metal; and, 2d, with two different kinds of metal. The production of a current by the first method is very decidedly shown by an experiment with platinum wire. Thus, cut the wire in two pieces, and fix each half in one of the binding-screws of a galvanometer. If one of the free ends be heated to redness and pressed against the other, the deflecting needle of the galvanometer will indicate that a current is passing from the cold to the hot end of the wire.

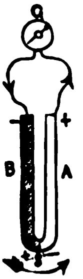

FIG. 20.

If two portions of the same metal, but of different structure, are heated at their junction, thermal currents are obtained.

Bismuth and antimony generate the strongest current by the second method. Let A and B be respectively bars of antimony and bismuth, soldered together, while G represents a galvanometer connected by two wires with the free extremities of the metals.

When the junction S of the metals is heated, a current of electricity is generated, which flows from the bismuth to the antimony, as shown by the arrow. If the junction S is chilled by applying ice, a current is also produced, but in the opposite direction. This combination constitutes a thermo-electric pair.

The following is the thermo-electric classification of the metals:

Bismuth	25
Cobalt	9
Potassium	5·5
German Silver	5·2
Nickel	5
Sodium	3
Mercury	2.5
Aluminum	1.3
Magnesium	1.2
Lead	1.03
Tin	1
Copper	1
Platinum	.7
Silver	0.
Gas Coke	—.05
Zinc	—.2
Iron	— 5.
Antimony	— 10.
Tellurium	—179.

Cold.

Heat.

The relative electro-motive force of the metals is indicated by the numbers. As in the electro-chemical classification, so here, the greater the difference between two elements, the greater is the electro-motive force. For example, the electro-motive force of a bismuth and antimony pair is 25 — (— 10) = 35, while of a bismuth and copper pair it is 25 — 1 = 24.

Figure 21 represents Farmer's thermo-electric battery, of which at one time strong hopes were entertained by electro-therapeutists. It was supposed that it would be a neat and convenient substitute for Smee's and other elements, that require acid solutions. These expectations have been disappointed. It has been found to be inconstant, unreliable, and less convenient than the batteries ordinarily employed. A prominent objection to its use in electro-therapeutics is the inconvenience of carrying in the machine an alcohol lamp in places where there is no gas. It has been used in electro-plating. Thermo-electricity was discovered by Seebeck in 1821; the thermo-electric pile was invented by Nobili, in 1834; the thermal effects of galvanic currents at the junction of heterogeneous metals was observed first by Peltier, in 1834.

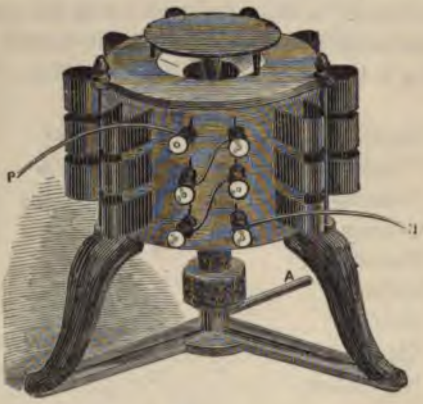

FIG. 21.

ELECTRO-PHYSIOLOGY.

ELECTRO-PHYSIOLOGY.

ELECTRO-PHYSIOLOGY *is the science which treats both of the laws of animal electricity and also of the physiological phenomena produced by the action of electricity on the body.* We propose to present this subject as compactly as possible, and consequently shall speak only of those facts that are necessary for a true appreciation of the science, and chiefly of those that, directly or indirectly, have a practical bearing on electro-therapeutics.

The more important principles of this department of electricity we shall announce in a series of propositions, following each proposition with its demonstration.

I. ELECTRIC CURRENTS EXIST IN THE TISSUES OF ALL ANIMAL BODIES.

Electric Fishes.—At a very early period it was known that a certain flat fish had not only the power, when touched, to give forth shocks, but could impart to other bodies for some distance through the water a benumbing influence. This phenomenon was first proved by actual experiment to be of an electrical nature as early as 1773; and soon after, by means of a number of Leyden jars, connecting with a disc of leather or wood, either side of which was covered by tinfoil, an artificial torpedo was constructed. By sinking this disc in the water, all the phenomena which had been obtained from the fish were readily observed. This peculiar power is possessed but by a small number of fish, the best known of which are the *torpedo* or *electric ray*, and the *gymnotus* or *electric eel.*

This development of electricity does not take place in all parts of the fish, but is confined to a peculiar expansion of the nervous system, called the electrical organ. The nerves constituting the electrical organs of the torpedo and gymnotus are of great size. Those of the former consist of three principal trunks, and arise from the cerebro-spinal system ; while the nerves composing the electrical organs of the latter are derived from the spinal cord alone. As stated above, the phenomena produced by these fishes are similar to those which are obtained from electricity that is artificially generated.

If electric fishes are touched with the hand a shock is perceived, while if glass, resin, or any other non-conductor is intervened no effect is produced. Sparks may be drawn from them in the same way that they are drawn from other bodies that are charged artificially with electricity. The current obtained from them will magnetize steel needles, decompose water, and if the needle of a galvanometer be brought into the circuit it will immediately suffer deflection, so that the direction of the current may readily be determined. The electric force of the fish is much weakened after it has exerted its power a number of times in quick succession, and it requires rest and nourishment to enable it to recover its normal vigor.

It is far more difficult to detect the existence of electric currents in other animals, but the researches of able explorers in this field have fully determined that they do exist. The nerves and muscles of all warm-blooded animals lose their irritability very rapidly after death, while those of the cold-blooded variety retain their irritability a long time. For this reason experiments are usually made with the frog.

Galvani discovered, in 1786,* and published in 1791, that muscular contractions followed the connection of the nerve and muscle of a frog by a heterogeneous metallic arc, and from this fact he was led to declare in substance that *animals have a special, independent electricity, deserving the name of animal electricity.* This, together with other declarations of Galvani, aroused intense enthusiasm among men of science. Physiologists were led to believe that the identity of life with electricity must soon be established. Galvani himself, from this hypothesis, attempted to explain all nervous conditions, and thus many physicians were inspired with the hope that, by the aid of electricity, all diseases might be cured.

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* Six years prior to this date, 1780, Galvani accidentally discovered that "the limbs of a recently killed frog, when hung by the crural nerve, on a metal support, near an electric machine, contracted convulsively at the recurrence of each spark." A comparison of this fact with that observed in 1786 suggested to him the theory of animal electricity.

At first, Volta accepted Galvani's theory of animal electricity, but subsequent research caused him to doubt its truth. He observed that it was only by means of heterogeneous metals that muscular contractions could *invariably* be produced, and hence he denied the existence of animal electricity, explaining the phenomenon of muscular contractions through the influence of the artificial electricity excited by a heterogeneous metallic combination.* Galvani then not only demonstrated that contractions could readily be caused by exactly homogeneous metals, but that the phenomenon was produced by the simple contact of nerve and muscle. His manner of experimenting was as follows: The leg of a frog, denuded of its skin, had its sciatic nerves cut at their exit from the vertebral column. The nerves thus denuded were taken gently up by some non-conductor and made to touch one of the muscles, when the leg would immediately become convulsed. Volta endeavored to prove that the *concussion* caused by the contact of nerve and muscle was the cause of the electric current thus produced; but Galvani conclusively demonstrated that such could not be the case, by placing a non-conductor between the two tissues, when no action could be excited in the leg. He went further, and at last succeeded in producing muscular contractions when the nerves only of non-prepared legs were brought in contact.

It would seem as if these elaborate and conclusive experiments of Galvani ought to have silenced all opposition, but Volta still remained unsatisfied, and for thirty years his views were generally accepted by natural philosophers, notwithstanding further proofs offered by Baron von Humboldt. In 1827, M. Nobili, having constructed a very sensitive galvanometer, was enabled to detect without doubt the existence of an electric current in the frog.

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* The theory that the experiment of Galvani could be explained by chemical action was first suggested by Prof. Fabroni, of Florence, in 1792.

He observed that when the needle was placed in the circuit it was deviated some 30°.

A few years subsequently, Matteucci turned his attention to this subject; but it was reserved for Du Bois-Reymond to demonstrate most clearly and conclusively the electric properties of nerves and muscles.* As a result of his elaborate researches, Du Bois-Reymond concludes:—

"1st. That currents in all respects similar to the so-called frog current may be observed in any limb of any animal, whether warm or cold blooded.

"2d. The electro-motive action on which these currents depend does not arise from the contact of heterogeneous tissues, as Volta supposed; for the different tissues—nerve, muscle, and tendon—in an electric point of view are quite homogeneous.

"3d. These currents are produced by the muscles."

"The current might be a downward, or it might be an upward one. The current of a whole limb is nothing but the resultant of the partial currents which are engendered by each muscle of the limb; and the frog current, as well as the similar currents observed in other animals, are thus simply reduced to a general muscular current." (Matteucci had also fully demonstrated the existence of an electric current in the leg of a frog, but had declared it to be peculiar to that animal alone; and therefore Du Bois-Reymond must be credited with the honor of having discovered that the "so-called frog current is merely a special case of a *general muscular* current.")

"4th. To make this law, according to which the current may be regularly obtained, more easily understood, it will be useful to premise some definitions.

"By *longitudinal section* of the muscle I understand the surface formed only by *the sides* of the muscular fibres considered as prisms. By ***transverse section***, is meant a surface formed by the base of these muscular prisms.

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* For a full description of the apparatus employed in these researches, as well as for a more detailed and exhaustive explanation of the laws of the muscular and nerve currents, the reader is referred to C. E. Morgan's work on *Electro-Physiology*, from which these extracts are taken; also Du Bois-Reymond's *Untersuchungen über thierische Elektricität*, Berlin, 1848 and 1853; Pflüger's *Untersuchungen über die Physiologie des Elektrotonos*, Berlin, 1859; and Von Bezold's *Untersuchungen über die Elektrische Erregung der Nerven und Muskeln*, Leipzig, 1861.

"Both transverse and longitudinal sections may be ***natural*** or *artificial*. This premised, I say: 5th, Any point of the natural or artificial longitudinal section of the muscle is positive (+) in relation to any point of the natural or artificial transverse section.

"6th. The nervous system—setting aside its own electro-motive power, which obeys the same law as that of the muscles—plays the part of an inactive conductor with respect to the muscular current, provided their own current (*i.e.*, that of the nerves) be prevented from entering the circuit."*

Parelectronomy.—The superficial layer of muscle may interfere with the current between the longitudinal and transverse section. Du Bois-Reymond has given to this layer the name parelectronomic, "contrary to the law." In the parelectronomic layer the electro-motive forces act in a direction opposite to those of the rest of the muscular substance, so that the natural current may be reversed or very feeble, or may be undemonstrable. Parelectronomy may be produced by the action of cold, and in a frozen frog the phenomenon is exhibited in a remarkable manner. As the frog becomes warmer the normal current reappears.

Tetanization.—When a continuous electric current passes through a nerve, it causes the phenomena of tetanus in that nerve.

The evidence of this tetanization is the movement of a jerking, twitching character, produced in the muscles connected with the nerve. By placing a stethoscope over a tetanized muscle it is possible to hear the ***susurrus muscularis***, or ***muscular murmur***, which corresponds in the number of its vibrations to the interruptions of the current. This same murmur can also be heard by closing the ears with wet paper and pressing the jaws firmly together, so as to put the masseters in powerful, uniform vibration. The sound heard is of a heavy, rumbling character. The experiment is most successfully performed in a perfectly still room. A similar murmur can be heard by placing a stethoscope over the muscles of the arm, or over the pterygoid and temporal muscles. *The negative variation* of the muscular current—that is, its decrease during contraction—is best studied by producing tetanus with the electric current. The needle of the galvanometer recedes, showing decrease of the current, during the entire persistence of the tetanus. Negative variation is explained by the theory that the peripolar molecules in the muscle change their arrangement, so that their electro-motor power becomes diminished.

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* Morgan, op. cit., p. 299.

The whole history of this immortal controversy between Volta and Galvani, and indeed all the experiments on the subject of animal electricity, are of exceeding interest; but for the practical purposes of electro-therapeutics it is more important to study the modifications of animal electricity, and other physiological phenomena produced by the applications of electricity to the human body. Currents have been found not only in the muscles and nerves, but also in the central nervous system. They are found also in the sympathetic. The muscle current and the nerve current are subject to the same laws, and are explained by the same molecular theory, which will be presented further on. Both the muscles and the nerves are supposed to be in a closed circuit. Electric currents are also found in the skin, spleen, testicles, kidneys, liver, lungs, as well as in the nerves and muscles. The sheaths of muscles, fasciæ, and sinews do not contain electricity.

ELECTROTONOS.

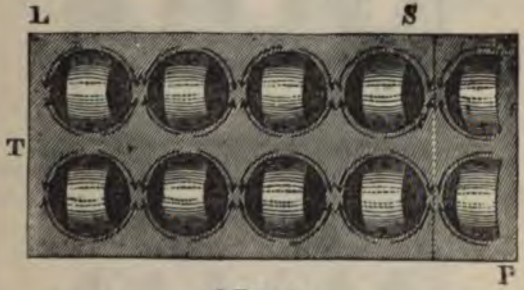
II. ***The electrical currents of the animal body, when subjected to the influence of a galvanic current, are variously modified, according to the position of the poles, and the strength and length of the application.***

When a nerve is electrized with the galvanic current a change takes place in the nerve-current, which is termed *electrotonos*. The change in the nerve-current depends on the direction of the galvanic current. When the galvanic current flows in the same direction with the nerve-current, the strength of the nerve-current is increased; when the galvanic current flows in a contrary direction, the strength of the nerve-current is diminished.

The extent to which these changes take place depends on various conditions. It is greater when the galvanic current flows lengthwise than when it flows across the nerve. It increases within certain limits, with the increase in the intensity of the current. It increases in proportion to the length of the portion of nerve that is subjected to the influence of the galvanic current. To develop electrotonos in nerves of animals which are greatly exhausted, or nearly dead, very powerful galvanic currents are needed. If the nerve be cut, or strongly ligated, electrotonos cannot be developed.

Electrotonos is also developed in a muscle in the same way as in a nerve; that is, by passing a galvanic current through some portion of it. Electrotonos in muscles is confined to the intra-polar space; in nerves it is also extra-polar.

Du Bois-Reymond's Molecular Theory of Animal Electricity.—Du Bois-Reymond has suggested a theory to account for the phenomena of electrotonos, which has been generally accepted. It is analogous to the theory of magnetism suggested by Coulomb. He supposes that muscles and nerves consist of electric molecules, which have one positive equatorial zone and two negative polar zones, whose axes are parallel to each other; that is,



* FIG. 22.

Peripolar Arrangement of Electromotor Molecules.
L S—Longitudinal Section.
T S—Transverse Section.
P—Parelectronomic Layer.

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* The copies of the drawings for these illustrations of the molecular theory were originally furnished the publishers by Dr. Neftel, for the *Medical Record.*

two molecules make one molecule. This is called the *peripolar* arrangement. In a magnet, each individual molecule manifests the same phenomena as the entire magnet. Each molecule is indeed a magnet in miniature. Precisely so, each molecule of the nerve or muscle manifests the same phenomena as the entire nerve or muscle. These peripolar molecules are enclosed by a moist covering.

Du Bois-Reymond further supposes that each peripolar molecule may be divided into a group of *di-polar* molecules—where the positive hemispheres are turned toward each other—without changing their electrical properties. This is called the *di-polar* arrangement. If a number of such molecules are brought under the influence of a galvanic current, their positive zones will turn toward the negative pole, and the negative toward the

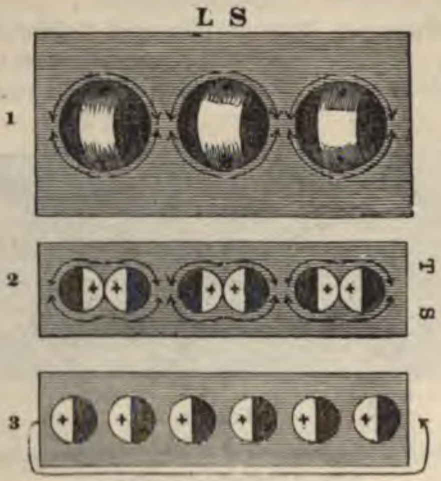

FIG. 23.

L S—Longitudinal Section. T S—Transverse Section.

1. Peripolar arrangement of electromotor molecules.
2. Di-polar arrangement of electromotor molecules.
3. Pile-like arrangement of electromotor molecules, caused by the action of the galvanic current.

positive; one of the molecules turning 180° on its axis. The arrangement will then be as above (3).

From its resemblance to the voltaic pile it is called the *pile-like* arrangement.

This theory explains the fact that a neutral point is always found in the middle of a voltaic pile.

Du Bois-Reymond has demonstrated these phenomena on molecules made of zinc and copper.

From these experiments Du Bois-Reymond concluded, first, that the nerve is always in the condition of a closed circuit, since electric currents are produced by the connection of layers surrounding the molecules with their molecules; and secondly, that the current obtained from an animal, as indicated by the galvanometer, is only a small portion of the entire current.

This pile-like arrangement of the molecules not only takes place between the electrodes, but also beyond them, into the extra-polar region.

The galvanic current that produces the electrotonic condition is called the *polarizing* current. The condition of changed irritability at the positive pole is called *anelectrotonos*, and at the negative pole, *catelectrotonos.* The portion between the poles is called intra-polar; beyond and outside of the poles, extra-polar. Electrotonos is *ascending* when it proceeds from the muscle to the nerve; *descending*, when it proceeds from the nerve to the muscle.

ANELECTROTONOS AND CATELECTROTONOS.

Anelectrotonos and catelectrotonos are changes in the *irritability* of a nerve, which take place when a galvanic current passes through a portion of it; that is, when the nerve is in a condition of *electrotonos.* Anelectrotonos is a condition of *diminished* irritability, which takes place at the positive electrode. Catelectrotonos is a condition of *increased* irritability, which takes place at the negative electrode. At some point between the electrodes the irritability of the nerve is unchanged. The conditions of anelectrotonos and catelectrotonos are found not only between the poles, but also in the other portions of the nerve—in the *extra-polar* portion.

This point, where the irritability is unchanged, varies with the strength of the current. When the current is weak the neutral point will be near the positive pole; when it is strong, it will be near the negative pole. When, therefore, a weak current is used, nearly all the portion of the nerve between the electrodes is in a state of catelectrotonos; when a strong current is used, nearly all the portion of the nerve between the electrodes is in a state of anelectrotonos. Catelectrotonos appears immediately after the closing of the circuit, and in its full strength; anelectrotonos, on the other hand, develops *gradually* after the closing of the circuit, but the more frequently the circuit is broken the more quickly it appears.

The portion between the poles and near the negative pole, together with the portion beyond the negative pole, is in a state of catelectrotonos, with increased irritability. The portion between the poles and near the positive pole, together with the portion beyond the positive pole, is in a state of anelectrotonos with diminished irritability.

The extra-polar catelectrotonos depends on the length of the nerve between the poles, and the strength of the current, up to a certain limit. The strength of the extra-polar anelectrotonos is proportioned to its distance from the poles, being greatest near the intra-polar portion. The extra-polar catelectrotonos, both ascending and descending, is in a state of increased irritability. The extra-polar anelectrotonos, both ascending and descending, is in a state of diminished irritability.

The power *of a nerve to conduct irritability is more or less modified* by the *condition of electrotonos.* The portion of the nerve near the positive pole, which is in a condition of anelectrotonos, has its conductibility diminished: the portion of the nerve near the negative pole, which is in a condition of catelectrotonos, has its conductibility increased. If the current be sufficiently strong, the power of the nerve to conduct impressions may be nearly or entirely destroyed.

PFLUEGER *discovered that a given nerve-piece is stimulated only* *by the appearance of catelectrotonos and the disappearance of anelectrotonos; not, however, by the disappearance of catelectrotonos and the appearance of anelectrotonos.*

To explain this principle more in detail, we may say that the irritation of the nerve, when a galvanic current passes through it, is not uniform; but that at the opening of the current it is near the anode,—at the closing, near the cathode. At the closing of the current, the irritation is due to the molecular changes which accompany the increased irritability at the cathode. At the opening of the circuit, the irritation is due to the change from the condition of anelectrotonos to the normal condition, which takes place when the current is interrupted.*

Effects of Electrotonos after the breaking of the galvanic (polarizing) current.—It is of importance, in a practical point of view, to understand the effect of the electrotonic condition on the nerve after the galvanic action has ceased.

One of the effects of the electrotonos is the *irritation* which is caused by the passing away of the anelectrotonos. This irritation, which appears at the positive pole, is shown either by contraction or by a tetanic condition.

The nerve which is in a condition of catelectrotonos in the extrapolar region is greatly modified by the breaking of the polarizing current. Its irritability is thereby very greatly increased. This increase of irritability is called the "*positive modification,*" in contradistinction from lowering of irritability, which is called "*negative modification.*" This increase of irritability continues for some time after the polarizing current is broken.

Another effect of electrotonos is the change of irritability which is caused by a change in the direction of the current.

If a nerve is subjected for some time to the influence of a galvanic current in a certain direction, it loses some of its irritability, which it regains when the current is reversed.

A very important effect of electrotonos is a restoration of irritability in a nerve. It has been proved, both by experience and by experiments, that nerves which from any cause have lost their irritability to the faradic current, sometimes regain it after an application of the galvanic. We have seen demonstrations of this law in the case of patients afflicted with paralysis of the facial nerve. It has been shown by the experience of several writers on electro-therapeutics, and of ourselves, that in cases of paralysis, when the faradic current at first fails to produce contractions, the application of the galvanic may not only readily produce contractions, but may also produce ***such a change in the irritability of the paralyzed parts as to cause them to regain their lost irritability to the faradic current.*** The superiority of the galvanic to the faradic current in such cases is supposed to be due to its greater chemical effects, owing to its more continuous action. (For detailed illustrations of the comparative effects of the galvanic and faradic currents, see *Paralysis.*)

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* Morgan, op. cit., p. 608.

A ***muscle***, like a nerve, may be put in the condition of electrotonos; the changes of irritability that accompany this condition are confined to the muscle through which the current flows. The subsequent effects, after the polarizing current is broken, are also limited to the portion through which the current passes.

It is logically probable also that not only the motor nerves, but also all parts of the nervous system—central and peripheral—are capable of exhibiting the phenomena of modified irritability under the galvanic current.

The laws of electrotonos are not only exceedingly interesting, but are very suggestive in a practical point of view. Although there may have been a tendency with some to over-estimate their importance in therapeutics, yet that they are worthy of study by all who employ electricity in the treatment of disease there can be no question.

The practical bearings of the phenomena and laws of electrotonos, so far as they appear to be established, will be indicated in the section on *Electro-therapeutics.* The phenomena of electrotonos are demonstrably produced only by the *galvanic* current.

Irritability of nerves is impaired by ***interrupting the circulation*** through pressure or ligature, by ***injuries***, and by ***extremes of temperature.*** When separated from the central nervous system, a nerve retains its irritability for several days, and muscles still longer. Irritability of a nerve is increased by moderate and diminished by very rapid electric stimulation.

The phenomena of the electrotonic condition of nerve, originally discovered by Pflüger in frog preparation, have been demonstrated on the living human subject by Erb and Eulenburg.

Direction of the Current.—Concerning the direction of the current, it is claimed to be established by electro-physiological experiments:

1. The ascending current increases excitability; the descending diminishes it.
2. The ascending current increases reflex action, while the descending diminishes it.
3. The ascending current acts most powerfully on the sensitive nerves, and the descending on the motor nerves.
4. The ascending current through the spinal cord acts upon the motor nerves by direct and not by reflex action; and, *vice versâ*, the descending current through the spinal cord acts upon the motor nerves by reflex and not by direct action.*

These established principles concerning direction of the current are believed to be of practical importance in electro-therapeutics. They are said to hold good without regard to the peculiar action of the poles; and are therefore, within certain limits, superior to the laws of electrotonos.

According to Legros and Onimus, "when we act upon the nerves and upon the centres in such a manner as to have a sufficiently great extent of nervous substance between the two electrodes, the direction of the current has a very marked action, because, according to its direction, and independently of the local action of the electrodes, it influences either the excitability of the motor nerves or of the sensitive nerves." †

III.—*The application of electricity to the surface of the body produces special physiological phenomena, according to the kind of electricity employed, its quantity, its tension, the position of the poles, and the locality and nature of the tissue where the application is made.*

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* Mémoires de la Société de Biologie. Mai 1868. (Quoted by Legros and Onimus.) Effects of Electricity on the Tissues of Nutrition. (Translated by Dr. J. Solis Cohen. Philadelphia: 1869.) See also Journal de l'Anatomie et de la Physiologie, 1870, p. 18.

† Op. cit., pp. 82, 83.

Effects of Static Electricity.—When the sparks of frictional electricity are applied to the skin they produce a sensation of pricking, and if the sparks are large the skin becomes red, and a papular eruption appears. When applied to the face, static electricity causes a very indistinct flash to appear before the eyes.

Effects of the Faradic Current.—When a faradic current of moderate intensity is applied to the skin by means of moist conductors, it causes a tingling sensation, but very little, if any, pain. The muscles are, however, immediately convulsed, and remain in a state of contraction until the circuit is broken. It produces less marked chemical effects on the parts through which it passes than the galvanic current, and influences distant organs very slightly by reflex action.

If the current is of low tension the contraction is feeble, and the sentient nerves are affected but slightly; but if the current is of great intensity, violent cramps of the muscles are produced, and acute pain is excited.

If the electrode is firmly pressed against the skin, at a point where the motor nerve is near the surface, the muscles supplied by that nerve contract. If any dry artificial electrode is pressed against the skin while a current is passing, the electricity will hardly penetrate to the deeper tissues, unless the current is very intense, because of the great resistance offered by the skin. The extremities of the sentient nerves are markedly affected, however, and pain is produced. When the dry hand is substituted for the dry artificial electrode, the surface can be faradized without producing pain. During the latter operation, the electricity acting upon the dry surface of the skin produces a peculiar crackling or humming sound that may be heard several feet.

An application of a faradic current of ordinary intensity is followed by the most marked effects on the skin when it is dry, from the fact that the electricity is mostly confined to the surface of this tissue. By this method of application the skin quickly becomes red, and if the current is made quite intense, circumscribed wheals are produced. A very fine, or, in other words, a rapidly interrupted faradic current has a more marked effect on the sentient nerves than a coarse or slowly interrupted current, and in the treatment of the more common forms of anæsthesia and neuralgia this fact must be considered. The negative pole has a much stronger effect both on the sensory and motor nerves than the positive. Any one can readily distinguish the poles, when both are held in the hands, by the stronger sensation which is felt at the negative. Some parts of the skin are more sensitive to the current than others, from the fact that they are more richly supplied with nerves. The face is especially sensitive at the points where the various branches of the trigeminus issue, and at the line of demarcation of the skin and mucous membrane of the nose and mouth.

A faradic current of moderate intensity, when applied to bones that lie very near the surface, produces considerable pain of a peculiar character. This pain is caused on account of the irritation of the sentient nerves of the periosteum. The forehead and the region of the scapula and tibia are especially sensitive to electrization.

It is not supposed that the bone is specifically affected by the electric current.

Both the periosteum and bone, however, may have an increased amount of blood attracted to them by electric excitation.

Acting in this manner, electrization has been known to reunite an old fracture.

EFFECTS OF THE GALVANIC CURRENT.

The galvanic current produces effects upon the skin that differ according to its intensity.

If its tension be slight, no effect is for the moment produced when it is applied to the surface of the body. If its strength be increased, marked redness of the skin is produced under both the positive and negative electrodes, the passage of the current is manifested by a burning pain that rapidly becomes more severe, and if continued for a sufficient length of time inflammation and destruction of the skin would be produced. The action of the constant current is far more decided upon the moist than upon the dry skin. If the epidermis be wholly removed before the application of the current the effect is very severe.

The following results were obtained by Baron Humboldt in 1795:—

Experimenting on himself, he raised two small blisters on either shoulder. When opened, the usual uncolored liquid was discharged from the blisters. The excoriated surfaces were then covered with two small pieces of silver. These silver pieces were connected with a zinc plate. The current thus produced caused inflammation, colored the discharge, and rendered it acrid.

The destruction of skin caused by the action of the galvanic current is most rapid and decided at the negative zinc pole, from the fact that at this pole a powerful escharotic, the chloride of zinc, is formed. The galvanic current possesses also marked reflex power; for when applied in the neighborhood of the fifth pair of nerves it affects the retina by reflex action, and the person upon whom the experiment is tried *sees* a flash of light.

This phenomenon is not produced by the faradic current, unless it is of remarkable intensity, or in peculiar cases of disease.

Electro-Anæsthesia.—It has for some time been a matter of dispute whether a slight anæsthesia can be produced by the electric current. It is well known that for a number of years some dentists have been accustomed to connect the forceps for extracting teeth with one pole of an electro-magnetic apparatus while the patient rested on the other pole, so that as soon as the forceps seized hold of the tooth a current is established. Although this method of producing anæsthesia is not now received with favor, there is no question that the electric currents do have a slight benumbing effect. The results of various experiments that we have from time to time performed in this department seem to be conclusive. We have had teeth extracted while a strong faradic current was passing through the jaw, and feel assured from this personal experience that the electricity caused the pain to be less sensitively felt. That the pain caused by the prick of a pin, for example, is less sensitively felt when a strong faradic current is passing through the part where the puncture is made, we have practically demonstrated on the hand and other parts of the body.

Althaus[*] arrived at the conclusion that the electric current could produce an anæsthetic or slightly paralyzing effects from experiments on the nerve trunks, as the ulnar and sciatic. His method of operating was to place the positive pole over some point where the nerve was superficial, and the negative over some one of the terminal branches, keeping up the action of the current for fifteen minutes, with the result of producing a feeling of numbness, and less sensitiveness to the current. Knorr, of Munich, has availed himself of the anæsthetic effects of electrization for opening felons and buboes.

We have also experimented on inflamed and irritated mucous membranes. In rhinitis, pharyngitis, and laryngitis we have for three years been accustomed continually to make use of the benumbing effects of electrization.

It has a very quieting and tonic effect on the irritated and inflamed mucous membrane, and those on whom it has been employed desire to have the applications repeated. Our custom is to use local faradization after the application of caustics and other irritants, in order to relieve the very annoying pain that they so often cause, or in any irritable condition of the parts.

Recently a French physician, M. Victor Revillout, has obtained similar results from applications of the faradic current to the uterus after cauterization.[†]

IV.—*Direct Electrization of the tubercula quadrigemina, the medulla oblongata, or the spinal cord, produces convulsions.*

Weber has investigated the action of the induced current, and Matteucci that of the galvanic, upon the brain of living animals. They found that electrization of the cerebrum or cerebellum was followed by no visible effect; but when the tubercula quadrigemina were brought under the influence of the current, clonic cramps were produced—similar in character to those associated with certain diseases of the brain. Electrization of the medulla oblongata or the spinal cord, on the contrary, produced tetanic convulsions. The heart's action may also be stopped by the action of the electric current upon the medulla oblongata.

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[*] Medical Electricity. 1860. pp. 166, 167.

[†] Archives Générales de Médecine. Septembre 1868. p. 356.

Rigid cramps *of all the muscles of the trunk and extremities* follow electrization of the spinal cord, when an electrode is placed at either extremity of the cord. Cramps of the same character are also produced when one electrode is applied to the anterior and the other to the posterior column, either at their upper or lower extremities.

If the spinal cord be divided at about its centre, and the lower half electrized, only the muscles of the lower or hinder limbs will contract. If the upper half be electrized, only the muscles of the fore limbs will enter into contraction. The results will be the same, whether the cut extremities are separated or brought in close contact, in which latter condition no impediment is offered to the passage of the current. Hence it is fair to conclude—

1st. That the muscular contractions observed are not due to the passage of the electric current from the nervous centre to the motor nerve,—but from the fact that electrization excites the inherent power of the cord, from which arise the muscular contractions.

2d. That the spinal cord is the nervous centre for all the muscles of the trunk and limbs.

At the moment of closing and breaking a galvanic current, its action upon the cord is manifest by the contraction of the muscles of the body and limbs; but during the passage of the current no contractions are observed. and a paralyzing effect soon takes place. The cord remains insensible to any stimulus that may be applied to it as long as the current is passing, but at its cessation any mechanical irritation will give rise to the usual tetanic convulsions. This diminution of excitability is confined alone to the spinal cord, for if the motor nerves and muscles are traversed by an induced current (while the cord is under the influence of the galvanic) they contract vigorously. The galvanic current applied through the spinal cord for a long time produces paralysis.

Although the electric currents—both galvanic and faradic—produce convulsions when applied directly to the spinal cord, or tubercula quadrigemina, yet no such effect is produced when the applications are made externally over the head and down the spine—although it is now well established that in all such external applications the brain and spinal cord are traversed by the current. The cervical sympathetic nerve, which animates the radial fibres of the iris, takes its rise from the spinal cord between the seventh cervical and the sixth dorsal vertebræ.

If this portion of the cord be galvanized, the excitation is transmitted to the cervical sympathetic nerve and thence to the iris, producing dilatation of the pupil. This point has been termed by Budge and Waller the *centrum cilio-spinale.* A ganglion near the fifth lumbar vertebra, which, on being electrized in animals, produces contractions of the rectum and bladder, is called the *ganglion genito-spinale.*

The first of these points, the *centrum cilio-spinale*, can be demonstrated by external applications, both of the galvanic and faradic currents, and is of great importance in therapeutics. The *ganglion genito-spinale* also is probably directly, though not so demonstrably, affected by external electrization of the spine,

V.—*All the phenomena observed after the section of the great sympathetic disappear when the cranial portion of the nerve is submitted to the action of the electric current, and in the living man the sympathetic can be directly affected by electrization.*

In 1727, M. Pourfour du Petit discovered that the following symptoms resulted from division of the cervical filaments of the sympathetic nerve ; viz., Contraction of the pupil, redness and injection of the conjunctiva, and flattening of the cornea ; the eyelids approach each other, the nictitant membrane becomes more prominent, the secretion from the mucous surfaces of the eye is increased, and the eyeball is drawn further into the orbit. In addition to these symptoms, the ears and nostrils also become red and injected, and the head hotter and more sensitive.

Claude Bernard observed that not only did all these phenomena disappear when the cranial portion of the nerve was submitted to electrization, but that they became even more decided in an inverse direction. The pupil became larger than natural ; the conjunctiva, the ears, and the nostrils became quite pale ; the eyeball protruded from its orbit; the mucous surfaces became drier, and the head cooler and less sensitive; but as soon as electrization was discontinued all the phenomena caused by the section of the nerve again appeared. Electrization of the great sympathetic before it is divided, produces almost precisely the same results as after division. Most of these phenomena that follow the section of the nerve are due to a relaxation of the muscular fibres of the arteries, by which their tension is diminished and their capacity increased, in consequence of which a greater volume of blood flows through the arteries. It has been observed by Professor Weber, that if either the inferior cervical ganglion of the sympathetic nerve or its cardial branches are submitted to electrization the action of the heart is accelerated, while electrization of the vagi stops its pulsation.

The splanchnic nerves arise from the six lower dorsal ganglia of the sympathetic.

Pflüger discovered that the action of the electric current on these nerves immediately arrests the peristaltic movements of the small intestines.

From this he concluded that the power of diminishing or arresting the peristaltic movements resided in the splanchnic nerves, which he termed the checking nerve system. Mr. Lister has, however, found that this power is possessed only by a strong electric current, while the stimulus of a mild current increases the peristaltic action.

The division of the sympathetic nerve modifies very markedly the effects of direct electrization of the ear. Section of this nerve causes, as we have seen, increase of heat in the ear. Now if the cephalic end of the divided sympathetic is electrified, the increased temperature of the part is lowered; but if the electric current is passed through the large diameter of ear, the temperature is further increased. On the other hand, if there has been no division of the sympathetic, and the ear is electrified, the heat in that part is lessened.

Valentin found that galvanization of the superior thoracic ganglion revived the pulsation of the heart after it had ceased, and increased the frequency of the beats when already in action. Von Wittich found that galvanization of the sympathetic caused very much increased salivary secretion in the parotid gland. Eckhard, however, did not obtain this result.

It is shown by the experiments of Kupffer, and Ludwig, and Pflüger that galvanization of the splanchnic either caused peristaltic movement or the reverse, according to the degree of the excitation.[*]

Our own experiments show that external electrization of the cervical sympathetic has a very marked influence on the pulse, in some cases accelerating the beat, in others producing the reverse effect, according to the degree and locality of the irritation; and also causes *marked changes in the vascular condition* of the retina. (See chapter on Sympathetic.)

Diplegic Contractions.—A very marked effect of the electric current upon the ganglia of the sympathetic are the *diplegic contractions*, which usually, though it is believed not necessarily, indicate a pathological condition.

The name diplegic (δις, and πλησσειν, to strike) was given by Remak to this form of contractions, because they were produced by placing the electrodes on two different points distant from the muscles in which they occur. The contractions are produced by placing the positive pole in the auricular maxillary fossa, and the negative by the side of the vertebræ, at some point below the sixth cervical. The theory of Remak, that these contractions were produced by the irritation of the superior cervical ganglion of the sympathetic, was confirmed by the experiments of Fieber[†] on animals, in which the superior cervical ganglion of the sympathetic was exposed. They can also be produced by other methods of electrization of the sympathetic. (See chapter on Sympathetic.)

VI. *The galvanic current acting on the optic nerve causes (by reflex action) a flash of light to appear before the eye.*

The action of galvanism on the retina was known to Volta nearly one hundred years ago. Duchenne was, however, the first to call general attention to this phenomenon. He applied the continuous current from a voltaic pile to the face of a patient suffering from paralysis of the portio dura. The victim of this experiment perceived, when the electrodes were applied, a bright flash of light, and exclaimed that the room was in a blaze. A total and permanent loss of sight was the result. No other similar accident from the application of the galvanic current to the face is on record. When the organ of vision is thus acted upon there is, of course, no real development of light. The flash is seen because the galvanism excites the vital energy of the optic nerve. Static electricity and the magneto-electric current act slightly upon the retina, but the faradic current—unless its tension is very great—can be made to affect it little, if any, except in rare pathological cases. The flash of light produced by galvanic excitation appears colored. When the positive pole is applied nearest the eye the light is blue; when the negative is applied nearest the eye it is orange-colored. The light is strongest when the positive electrode is placed at a point corresponding to the *macula lutea*, and darkens as it is placed at a point nearer the periphery of the field; while if the negative electrode is applied to the same point the light is less brilliant, but becomes brighter when it is moved towards the periphery of the field.

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[*] Quoted by Edes in his prize essay on the Physiology and Pathology of the Sympathetic and Ganglionic Nervous System. Transactions of the Academy of Medicine, vol. iii., part viii., 1869, p. 78.

[†] Die diplegischen Contractionen nach Versuchen an Menschen und Thieren, p. 21. Berlin: 1866.

According to Helmholtz, the action of the downward current, darkening the visual field, proves that the electricity both stimulates and alters the irritability of the nerve. Since this appearance of light takes place by reflex action from the branches of the fifth pair to the retina, it is produced when the electrodes touch any point, provided the part is supplied by a filament of the trigeminus. Consequently, if one electrode is placed on the tongue, or on any part of the mucous surface of the mouth or nose, and the other on any part of the surface of the body, the flash is readily perceived. We have observed, also, on several occasions, that when the eyes were inflamed the current produced a brighter sensation of light than usual.

VII.—*If a current of electricity be passed through the drum of the ear, sounds are heard by the one on whom the experiment is tried,*

and the auditory nerve can be made to react to the galvanic current in a regular manner.

These sounds are as readily excited by the faradic as by the galvanic current. The character of the sounds produced, however, differs with the current used, and the electrode with which the application is made, the negative possessing greater power than the positive.

Ritter observed that the pitch of the tone heard, when a direct galvanic current was passed through his ears, was G, and as the intensity of the current was increased the sound became higher. An inverse current produced a sound lower than G, and which continued to grow still lower so long as the current increased in intensity. During electrization of the membrana tympani the chorda tympani is excited, thus producing an unpleasant metallic taste and a flow of saliva. The first of these phenomena is accounted for from the fact that this nerve enters into the tongue, and contributes to the perception of taste.

The explanation of the second phenomenon is, that some fibres of the electrified chorda tympani are distributed to the sub-maxillary ganglion. The disputed question whether the auditory nerve can be made to react to the galvanic current would now appear to be definitely settled.

According to the experiments of Brenner, that have been confirmed by Erb, the auditory nerve reacts to the galvanic current by certain fixed laws.

This normal formula, as represented by Erb, is as follows: *

Ka S Kl, distinct accented sound.

Ka D Kl >, sound disappearing by degrees.

Ka O —, no sensation of sound.

An S —, " " "

An D —, " " "

An O Kl, weak and short sound, similar in character to Ka S.

In the above formula, Ka = Kathode (negative pole), An = Anode (positive pole), S=closing (schliesung), O=opening (oeffnung), D=duration of current.

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* See Dr. Pooley's translation of Dr. Erb's paper on the "Galvanic Reaction of the Nervous Apparatus of Hearing of Health and Disease," in Archives of Ophthalmology and Otology, Vol. I., No. 1.

Pf =whistling sound.
Kl=ringing "
Z =hissing "

These experiments, which were made with currents of moderate intensity—from 10 to 15 elements—were attended with considerable difficulty, and, on account of the great sensitiveness of the external auditory canal and membrana tympani, can only be successfully made after long and careful practice.

With some persons the pain is so intense that the experiments cannot be satisfactorily conducted.

The results obtained by Brenner and Erb accord with the contraction law of Pflüger, and the accepted views concerning the polar action of the galvanic current.

The leading idea obtained by these experiments is that, *on the closing of the current the excitement appears at the cathode* (Ka), *on the opening of the circuit at the anode* (An).

The excitement at the cathode at the closing of the circuit is manifested sooner and stronger than that which takes place at the anode on the opening of the circuit.

Any deviation from the above law is to be considered abnormal, and indicates some pathological condition.

The diagnostic and therapeutic bearing of these experiments will be discussed in the chapter devoted to the treatment of diseases of the ear.

The mode of application employed by Erb was to place the cathode in the external auditory canal previously filled with warm salt water, or pressed firmly against the tragus, so as to close the auditory passage, while the anode is fastened to the back, on the side opposite the ear which is under examination.

The acoustic reaction which follows this method of application is complicated not only with pain, but also by dizziness, flashes of light before the eyes, contraction of the masseters, and in some cases by nausea.

VIII. *Is the Schneiderian membrane directly* [illegible] *intense current of galvanic or frictional electricity, the persons on whom the experiment is tried will experience a peculiar smell.*

Ritter says that a peculiar smell is excited that continues some time after the circuit is broken. Meyer has perceived an "increase of the mucous secretion, as well as a pricking, stinging sensation in the nose." If the current be in an inverse direction, there is an acid smell and loss of the power of sneezing at its commencement, and so long as it continues to pass; while at its cessation, and for a short time afterwards, there is an ammoniacal smell and an inclination to sneeze.

On the contrary, if the current is passed directly towards the periphery, the order of these two phenomena is reversed.

Schönbein affirms that the peculiar smell experienced from the passage of the electric current is caused by the ozone produced by the action of the electricity on oxygen.

IX.—*If two heterogeneous metals, such as zinc and silver, are applied to the tongue, a peculiar sensation of taste is excited.*

This fact was known many years before the discovery of galvanism. In 1754 it was noticed by M. Sulzer that lead and silver, when connected, and then brought in contact with the tongue, gave rise to a peculiar taste, similar to that produced by vitriol of iron. If we apply a piece of zinc to the upper, and one of silver to the lower part of the tongue, a powerful acid taste will be experienced under the zinc plate, and a slight alkaline taste under the silver plate. These sensations are perceived as long as the circuit is closed, but if the plates or the tongue be much warmer or colder than natural, very little if any sensation is produced. If the tension of the current be much increased, by using several pairs, the tongue becomes convulsed, and a flash of light is perceived. When neither of the electrodes touches the tongue a *metallic* instead of an acid or alkaline taste is produced. In susceptible patients a metallic taste is produced by galvanization *of the spine and even of the extremities.*

Sparks from a frictional machine affect the tongue in a manner somewhat similar to galvanic electricity.

X.—*The interrupted galvanic current, acting upon a motor nerve, will cause all the muscles supplied by that nerve to contract.*

Galvani discovered that muscular contractions were produced at the moment the nerve and muscle of a frog were connected by means of a heterogeneous arc of metal. Volta found that contractions were as readily produced when the nerve alone was enclosed in the circuit, and Valli, an Italian philosopher, observed that another contraction followed when the circuit was broken. In order that this phenomenon may be observed, it is necessary that the current traverse the nerve in an oblique direction. A current passed transversely through would cause no sensible effect. The galvanic current has no power to produce contractions without the nerve is in a state of integrity. If a wet thread be tightly wound around a motor nerve, no strength of current, if applied above the point of ligature, would be sufficient to affect the muscles supplied by the nerve, although the electricity will pass as readily as ever. Again, let a motor nerve be submitted to the action of the woorara poison, and electricity is powerless to cause the muscles which it supplies to respond to its action. We have observed that a continuous galvanic current of uniform intensity produces no visible effects on the muscles between the closing and opening of the circuit. If, however, we vary the intensity of the current in any way, contractions will be produced as readily as when the current is opened or closed. Hence it was concluded by Du Bois-Reymond that "the motor nerve is not excited by the absolute amount of the density of the current, but merely by the variations which occur in the density of the current from one instant to another; and the physiological effect is the greater, the more considerable are the variations of the density of the current; that is, in proportion as they take place more rapidly, or as they are more considerable in a given space of time." If the current is interrupted slowly the contractions will be *clonic*, if rapidly interrupted the contractions will be *tonic*.

On account of these remarkable physiological phenomena it would be unsafe to make use of a galvanic current of sufficient intensity to accomplish in certain cases the necessary therapeutical result, if we had not at our command a ready method of controlling its effects. The violent contractions that occur at the moment of closing and opening the circuit of an intense current may be avoided, if we begin with an extremely mild current and slowly and gradually increase its tension.

By this method Ritter was enabled to pass through his own person, without experiencing either the closing or opening shock, the enormous current generated from a battery of 200 elements.

The fluctuations of the current may be readily controlled by the means of the rheocord devised by Du Bois-Reymond.* The rheostat is, however, for practical purposes, equal if not superior to the rheocord. Of the various apparatus constructed with this improvement, that of Siemens and Halske is probably the best.

From the explanation of Du Bois-Reymond, quoted above, we can readily understand the action of the induced or faradic currents upon nerves and muscles. They are instantaneous, and succeed each other more or less quickly, according to the rapidity with which the circuit of the battery is closed and opened. By means of the rheotome the intermittences may be made so rapidly that the intervals between the contractions are too short to be distinguished, and consequently appear continuous, as if produced by the will. A muscle subjected to the influence of an interrupted current contracts with vigor only at the points where the electrodes are placed. In order to produce complete contractions of all its fibres, therefore, it is necessary to bring the electrode successively in contact with every portion of its surface.

In producing the phenomenon of contraction, the *intensity* and *direction* of the current, as well as its variations, are of great importance. The galvanic current alone has the power to cause calorific and chemical action sufficient to destroy a nerve. If it be interrupted, however, by means of a rheotome it is no more efficacious in this respect than the faradic current. If an uninterrupted galvanic current of feeble intensity be applied to a nerve, it (the nerve) will retain its excitability a long time; but if the tension of the current be very great, the excitability of the nerve will soon be destroyed, and it will cease to respond to the electric stimulus.

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* Beschreibung einiger Vorrichtungen, pp. 119–131.

This effect is due to electrolysis. The nerve is cauterized by the action of an alkali liberated from the salt solution, and in consequence of the decomposition of the water, hydrogen is developed around the negative pole, where the most marked chemical and calorific action takes place.

If a nerve thus injured be submitted to the influence of an induced or a mild galvanic current along the course already acted upon by the current, no contractions will be produced. But if the electrodes be placed below the point where the negative pole has been situated, so that the current may traverse a portion of the nerve that has not been subjected to electrization, it will again animate the muscles supplied by the nerve.

In observing the phenomenon of electric contraction the direction of the current is also to be considered. The motor nerves are excited differently, according as the current is descending or ascending.

This is very well illustrated by experiment with a frog, prepared after the manner of Galvani. If either leg is connected with the pole of a galvanic pair, it will be observed when the current is established that contractions do not take place in both limbs at the same time. At the moment of closing the circuit, the leg in which the current is descending becomes convulsed, while at the moment the circuit is broken, the leg in which the current is ascending suffers contraction. In order to perform this experiment successfully, it is not only necessary that the current be very feeble, but that the nerve should have lost a certain amount of its excitability, as is the case a short time after death, and also after it has been influenced by the galvanic current for a long time.

In the dead animal, after a certain time has elapsed, the descending current only will cause contractions, and finally the nerves lose completely their electro-muscular contractility. These phenomena have excited the attention of several explorers in this department, but especially of Nobili of Reggio.

He distinguished five different degrees of the excitability of the nerves, three of which may exist at the same time in the same nerve.

Ritter, who was the first to give any special attention to this subject, observed that a weak descending current from a single galvanic pair exercised after a certain length of time a *paralyzing* action on the nerve, while the ascending current augmented its irritability. The irritability of a nerve thus lost by the descending is readily regained by the use of the ascending current.

Volta, in experimenting with a current of greater tension, found that both the descending and ascending currents exercised a paralyzing influence after a certain time; but when the nerve had lost its irritability through the action of either, its vigor was readily restored by the use of the other current. These results of Volta were afterwards confirmed by Marianini. The most important experiments concerning the action of galvanism on irritated nerves were made by Prof. Eckhard, with only two of Daniell's cells.

From his researches he concluded that the ascending current may, after a certain length of time, diminish the excitability of a *tetanized* nerve throughout its whole course, while the descending current diminishes its excitability at those points only beyond the positive pole, and where the electrodes are placed. Eckhard's conclusions were drawn exclusively from trials made upon nerves separated from the body. Bernard experimented upon nerves whose connection with the spinal cord had not been severed, and thus obtained very different results.

A galvanic current, either descending or ascending, passed through a nerve while in its normal physiological condition, produced contractions only at the moment the circuit was closed. If the nerve was somewhat exhausted from any cause the current produced contractions, not only at the closing, but at the opening of the circuit. If the exhaustion of the nerve was more marked, contractions were caused only on closing the descending and breaking the ascending current; and if the exhaustion became still greater, only a single contraction could be observed on closing the descending current.

By an effort of the will it is easy to resist successfully the action of the uninterrupted current within certain limits. To cause continued and powerful contraction by galvanism while the circuit is closed, it is necessary that the current be of such enormous tension that frequently great pain is excited. It is rarely, if ever, necessary in the treatment of disease to produce such violent effects. Remak terms the contractions produced in this manner, *galvanotonic.*

Having seen that galvanic irritation of a motor nerve causes the muscles supplied by that nerve to contract, the question naturally arises as to the existence or not of a *vis musculosa insita.* In other words, may the irritability of the muscle be a property inherent in the muscular fibre itself?

An insurmountable obstacle for many years to the solution of this question was the great difficulty experienced in preparing muscular fibre without nerve fibrils.

Haller was the first to declare that irritability was a property inherent to the muscular fibre.

He was maintained in this opinion by Volta, Longet, Marianini, Matteucci, Bowman, Claude Bernard, and others, while Marshall Hall, Humboldt, Weber, Muller, Eckhard, Remak, and others opposed him.

Notwithstanding the careful researches of these investigators, the question still remained unsettled, from the fact that no one had attempted to prove Hallerian irritability by means of muscular fibre from which all nervous fibrils had been eradicated.

Bowman took the first step in this direction, but his proofs were not conclusive. Claude Bernard then commenced his researches on the physiological action of the woorara poison, and notwithstanding the objection of Eckhard, advanced convincing proofs of the existence of an irritability proper of the muscles. Woorara, it is well known, is the most deadly poison, and immediately destroys the integrity of a nerve. Bernard found, if a small piece of this substance was introduced under the skin of the leg of a prepared frog, until it ceased to show signs of life, and then the galvanic current was passed through a portion of the lumbar nerve, not the slightest convulsions of the muscles were produced. If the electrodes were applied directly to the muscles, immediate contractions were produced.

Both Kölliker and Althaus have confirmed by their experiments the researches of Bernard; thus rendering it evident that the electric current may disturb the molecular equilibrium of muscles deprived of all nervous matter, as well as that of the nerves.

It will be observed, however, that by exciting the trunk of a motor nerve, all the muscles supplied by the branches of that nerve will be brought into contraction; while if the current be applied directly to the muscle, only those fibres contract that are directly affected by it.

The molecular equilibrium of the nerve fibre is much more easily disturbed by the electric current than that of the muscular tissue, whether a feeble current, ascending or descending, produces contraction at the closing of the circuit.

Different Action of the Galvanic and Faradic Currents in producing Muscular Contraction.—Muscles, when in health, contract more readily under the influence of the faradic current than of the interrupted galvanic. In certain paralysis of various parts of the body, and especially of the face, the muscles lose their excitability to the faradic current, while the interrupted galvanic produces contraction in them more easily than in healthy muscles.

As the muscles improve, and in proportion as they regain their irritability to the faradic current, in that proportion do they lose it to the interrupted galvanic current.

These phenomena, which have been demonstrated by a variety of observers (see chapter on *Paralysis*), are to be explained by the fact that muscular fibre in disease undergoes degeneration that makes it incapable of responding to the electric influence as *rapidly* as in health. Now the interruptions of the faradic currents are exceedingly rapid, and do not give the diseased degenerated muscle sufficient time to contract under its influence. The interruptions of the galvanic current may be made as slowly as the operator desires, and therefore give the muscles all the time needed for contraction. In healthy muscles, on the contrary, the interruptions of the galvanic current are not made as rapidly as is necessary to bring out their full contractile power, while the interruptions of the faradic current are always exceedingly rapid, though no more so than the healthy muscle requires.

The power of the galvanic current to produce contractions, when the faradic fails, is probably also in a measure due to its greater chemical properties, and this, in turn, to its longer continuance of action.

PFLUEGER'S LAW OF CONTRACTION.

A feeble current, whether ascending or descending, produces contraction at the closing of the circuit.

A current of moderate intensity, ascending and descending, produces contraction both at the opening and closing of the circuit.

A strong current, when ascending, produces contraction at the opening, and when descending, contraction at the closing of the circuit.

According to Marianini, the ascending current produces more contraction at the closing and opening of the circuit; and the descending, more pain at the closing, opening, and after the closing of the circuit.

Electro-muscular Contractility and Electro-muscular Sensibility.—The susceptibility of the muscle to contract under the influence of the electric current is called *electro-muscular contractility.* The sensation that accompanies this contraction of the muscles under the electric influence is called *electro-muscular sensibility.* Electro-muscular contractility and electro-muscular sensibility vary in different individuals, and in different parts of the body. They are greatly modified by disease. This fact is of great importance in diagnosis of paralytic affections.

This will be pointed out more fully in the chapter on *Electrization as a Means of Diagnosis*, and in the section on *Paralysis.*

The electro-muscular contractility and sensibility of the muscles in the different parts of the body are modified, *first*, by the anatomical position of the muscles; *secondly*, by the quantity and distribution of the sensitive nerves; and *thirdly*, by the thickness of the skin and adipose tissue.

The muscles of the face, the *platysma* myoides and sterno-cleido-mastoid are, in health, very sensitive to the electric influence. Next in order of sensitiveness to the electric current are the anterior muscles of the forearm and of the inner side of the thigh. On the other hand, the muscles of the back possess a much less degree of electro-muscular contractility and sensibility, and the posterior muscles of the forearm, and posterior and other muscles of the thigh, are much less susceptible to the electric influence than those of the anterior and inner portions of these limbs. In corpulent patients it is more difficult to affect the muscles, because adipose tissue is comparatively a poor conductor.

Increase of Temperature after Muscular Contraction.—It has been ascertained, by careful experiments, that an increase of temperature results from muscular contractions produced by the electric current. The rate and extent of the increase will depend on the energy of the contractions, the length of the treatment, and the pathological condition of the muscles. Trousseau caused an elevation of temperature of 4·4° C. from a treatment of ten minutes. Increase of temperature in the muscles of paralyzed limbs, after electrization, is frequently perceptible to the touch of the operator and the sensations of the patient. The temperature rises during electrization only up to a certain limit. According to Ziemssen the temperature of the arm during electrization with the faradic current is at first a little depressed, but after the third minute rises for one or two minutes, when it reaches its maximum. We have repeatedly demonstrated the same results from faradization of the arms, the legs, the face, and indeed all parts of the body. In very many cases this increase of temperature is so marked as to be powerfully appreciated by the patient, and entirely perceptible to the hand of the operator. General electrization causes more or less elevation of the temperature of the body. This is demonstrated by the sensations of the patient.*

The primary lowering of the circulation during faradization is due to the contraction of the blood-vessels; the subsequent elevation is mainly due to the chemical changes that attend muscular contractions.

It has been shown by Brown-Séquard and Lombard that excitation of the nerves of the skin causes an increase of temperature in the limb.†

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* Electricität in der Medicin, 1866, p. 29.

† Archives de Physiologie, November and December, 1868.

Schiff declares that the nerve is raised in temperature by the instantaneous passage of a faradic current.*

The development of heat is not aided by increasing the strength of the current above the degree necessary to produce a full contraction.

It has been demonstrated that, in patients afflicted with traumatic tetanus, there is great increase of temperature, that remains for some time after death.

The investigations of the chemical changes that take place during muscular contraction have led to many experiments. It is the view of Hermann, who has labored patiently in this department, that "muscular work is due to the decomposition of a nitrogenous substance, and that among the products of this decomposition—viz., carbonic acid, a fixed acid, and myosine jelly—the latter, at least, and perhaps also the fixed acid, are used to renew the original body; whereas the carbonic acid certainly leaves the muscle and the organism." †

XI.—*The organic muscular fibres of the abdominal and thoracic viscera respond more readily to the influence of the faradic than the galvanic current,* and *when subjected to electric excitation they contract in accordance with the law of their physiological action.*

It is observed, however, that when the galvanic current is applied to them, contractions are produced not only soon after the circuit is closed, but also during the whole time that it remains so.

Contractions are produced in a voluntary muscle the instant the poles of a galvanic battery, or of an electro-magnetic machine in operation, are applied to it. As has been before stated, the contraction of the muscle continues during the passage of the faradic current, but quickly relaxes after the first shock of the galvanic. When, however, the intestines, the stomach, the œsophagus, which are composed of organic muscular fibre, are subjected to galvanic excitation, movements are not induced in them until a certain time after the tissue has been acted upon. The movements thus excited continue for a time after the cessation of the current.

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* *Observations on the Effects of Electric Currents upon the Living Tissues and upon Nutrition*, by MM. Legros and Onimus, translated by J. Solis Cohen, M.D., 1870, p. 20.

† Morgan, op. cit., p. 580.

When fibre-cells are subjected to electric excitation, they contract in accordance with their physiological action. Thus, electrization of the intestines induces peristaltic movements; of the œsophagus, contraction of the longitudinal and of the circular fibres; of the stomach, a shortening of the longitudinal and transverse diameters, the direction of the movement being from the cardiac to the pyloric extremity.

It has been shown by Bernard that electrization of the spleen produces sensible contraction of its organic muscular fibres.

MM. Legros and Onimus,* from recent experiments, arrive at the following conclusions:

"Inductive † currents, applied directly to the intestines, produce a contraction at the level of the poles; between the poles there is a relaxing of the walls.

Continuous currents abolish peristaltic movements and produce a diminution of tension, if the current follows the normal direction of the movements, or an augmentation, if the current passes in a contrary sense.

Electrization of the spinal cord by continuous currents increases notably peristaltic contractions at the moment of their application.

The inductive currents upon the splanchnic nerves cause a progressive increase of the tension without producing peristaltic movements.

Continuous currents upon the splanchnic nerves cause peristaltic contractions.

Electricity brought to bear upon the nervous plexuses and the mesenteric nerves produces analogous results.

The salivary glands are not affected by direct electrization. Electrization of the lingual and auriculo-temporal nerves, chorda tympani, causes very free flow of saliva, with enlargement of the blood-vessels of the glands; galvanization of the sympathetic arrests the flow. That galvanization through the neck and upper portion of the spine increases the flow of saliva, is a matter of daily observation.

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* European Medical News, January, 1820, p. 41.

† See explanation of the terms here translated as "inductive," "continuous," and "interrupted," in *Glossary*.

Electrization of the gall-bladder causes bile to be voided into the duodenum; and of the urethra, contraction in the direction from the kidney to the bladder. Contractions of the uterus may be produced by electrization, whether it be in the gravid or non-gravid state.

The bladder, vas deferens, epididymis, and tunica vaginalis may all be readily brought into contraction by the electric current.

The smaller arteries are influenced very readily by electrization, while it is doubtful whether the aorta can be made to contract at all. This is accounted for from the fact that the smaller arteries are well supplied with contractile fibre-cells, while the aorta is comparatively destitute of them.

The pupil of the eye may be dilated or constricted, according as the current acts upon the dilator or constrictor muscle of the iris. The iris is influenced by electrization of the cervical sympathetic.

XII.—*Galvanization of the heart produces various phenomena, according to the strength and locality of the irritation.*

The heart has four sources of nerve-supply: the sympathetic ganglia in the substance of the heart, the cervical sympathetic, the cardiac nervous centre in the medulla oblongata, and the depressor nerve, from the superior laryngeal.

If the ventricle and atrium of the heart of a frog, which are supplied by filaments from the vagi, be electrified, it becomes constricted and its pulsations cease. When the bulbus aortæ (which receives its nervous supply from the sympathetic) is submitted to electrization, the action of the heart is augmented.

By experiments on animals it has been found that if the vagi be divided and the upper end electrified, the eyes become markedly affected. They protrude, and the pupils dilate. As soon as the action of the current ceases the pupils are constricted, and the eyes resume their normal position.

If the current be of considerable power, inspiration is impossible, and all the symptoms of asphyxia present themselves. As soon as the electric influence is withdrawn the respiratory movements again succeed each other as usual, and with increased velocity. The following results are observed after this operation, viz.:—the cerebro spinal liquid, the blood, and the bile contain sugar; there is an increased flow of saliva, while the secretion of urine may be arrested. The pulsation of the heart is in no way affected. Electrization of the lower ends does not stop the respiratory movements; but it arrests the action of the heart, and may cause vomiting.

Rhythmical contraction may be produced in the heart of an animal soon after death by the action of the faradic current. It is observed that the contractions are more decided in the right than in the left portion of the heart.

XIII.—*The electric currents have a marked chemical effect on the blood, and decidedly influence the circulation.*

By means of the galvanic current, blood circulating in the living body, as well as that which has been taken from it, may be readily coagulated. Different results are produced by the action of the current on the blood, according as the latter is arterial or venous. Clots that may be formed by this method in the veins are darker and far less firm than those that are formed in the arteries.

In experimenting on albumen with the galvanic current different results have been obtained.

According to Althaus, the effects of the continuous galvanic current on albumen are, at the *negative* pole, mechanical disintegration of its substance by the nascent hydrogen, and chemical alteration by caustic potash, soda, and lime; at the *positive* pole, chemical alteration by chlorine and acids. The same changes take place in the blood, but are somewhat modified by the presence of iron, fibrine, and hæmatine. "Coagulation takes place at both poles, with only this difference, that the negative clot is red, soft, and bulky, while the positive clot is black, hard, and small."

The primary effect of electrization with interrupted current is contraction of the arterioles with diminution of the circulation. It may, indeed, entirely arrest it.* After the electrization ceases the vessels may be enlarged and the circulation increased.† The action of the galvanic current is different. The descending current, from the centre toward the periphery, dilates the blood-vessels; the ascending current, from the periphery toward the centre, contracts them. This was demonstrated on the brain of a dog whose skull had been trepanned. "Placing the positive pole upon the exposed portion of the brain, and the negative pole upon a wound in the neck (10 Remak elements), a contraction of the vessels was determined, and the brain faded slightly, but in a visible manner. Placing, on the contrary, the positive pole upon the wound in the neck, and the negative pole upon the brain, we observed an injection of the cerebral capillaries, and the brain formed a protrusion through the opening in the cranial vault."‡

Uspenski found that the ascending continuous current through the spinal cord of a frog increased its irritability, while the descending diminished it. Legros and Onimus also lay down the general law that the ascending current increases the reflex actions of the spinal cord, while the descending prevents them. The relation of this difference in the effects of the ascending and descending currents to the changes in the circulation are not yet sufficiently clear to guide our therapeutics. The subject demands further study.

We have proved that galvanization of the cervical sympathetic produces at first congestion and afterwards anæmia of the brain (see chapter on *Sympathetic*).

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* Dr. Althaus, in his paper on the "Electrolytic Treatment of Tumors," etc., (London, 1867), asserts that the negative pole produces firmer coagulation than the positive, since it merely diminishes or retards the circulation, and thus causes a slow deposition of fibrin. "The walls of the aneurism are strengthened, and it is enabled to resist the action of the heart until the time when the cavity of the heart is finally obliterated." It is proper to state that Dr. Althaus has not had an opportunity to operate upon an aneurism by this method. He drew his conclusions from experiments on rabbits, in which he had obliterated the femoral artery.

† Legros and Onimus, op. cit., pp. 30–31.

‡ Legros and Onimus, op. cit., pp, 34–35.

XIV.—*The electric currents have a powerful influence over nutrition.*

It has been shown by experiments that the galvanic current causes a marked electrolytic effect on the tissues. The acids go to the positive pole, and the alkalies to the negative, and there is an increase of temperature. It has been shown, also, that the red corpuscles of the blood are dissolved by the alkalies at the negative pole, and caused to shrink by the acids at the positive pole. Under the discharges of a Leyden jar the red corpuscles change their shape and lose their color.

The very remarkable tonic effects of both the galvanic and the faradic currents on the living human subject are to be explained partly by the *direct physical and chemical action of the electricity*, and partly by the changes of tissue that accompany muscular contractions.

The increase in heat that results from muscular contractions, with the corresponding increased absorption of oxygen, the modifications of endosmosis and exosmosis, the changes in the form and color of the red corpuscles of the blood, and the dissolution by the alkalies of the negative pole, and shrinkage by the acids of the positive pole—all the recognized molecular and chemical phenomena that result from electrization of the tissues help to account for the wonderful and sometimes rapid increase of weight, with improvement in all the vital functions, that result from a persevering use of general electrization. Details of illustrative cases of improvement in nutrition from electrization will be found under the various diseases.

Legros and Onimus* electrized with the galvanic current some puppies for a quarter of an hour every day, by placing one of the fore-paws and one of the hinder-paws in tepid water connected with the electrodes. At the end of six weeks those that had been electrized weighed more than one of the same lot that had not been electrized; and this difference was perceptible to simple inspection.

The same observers record that "continuous centripetal currents exaggerated the production of urea,* without increasing the secretion of urine, which is even sometimes diminished." The continuous centrifugal currents had a reverse effect.

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* Op. cit., p. 88, et seq.

It has been shown by the experiments of Legros and Onimus that the laws of endosmose are reversed by the galvanic current. Previously it had been shown by Dutrochet that the electric currents increased endosmotic action. The extra faradic current had something of the same effect, though in a far less degree.†

It has also been shown by Prevost and Dumas, as well as by Legros and Onimus,‡ that the vibratile cilia of the frog are accelerated in their movement by the galvanic current, and retarded by the faradic current. Substantially the same results were derived from experiments on spermatozoa.

XV.—*The human body conducts electricity by virtue of the saline solutions which it contains.*

The chief constituent in the human body is water, which is about three-fourths of its average weight.§ The saline constituents which the water holds in solution vary in quantity and quality in the different tissues and the different parts and organs of the body.

The conductibility of the body, as a whole, may be best understood by regarding it as a mass of water and saline ingredients, with solid tissue interspersed. The degree of resistance to the current that different parts of the body offer will therefore depend on their structure. Those parts which, like the bones and epidermis, contain little water, will offer a much greater resistance, and be poorer conductors, than those parts which, like the muscles, nerves and tendons, and cartilages, contain a large percentage of water. Soft parts, like the stomach, intestines, and mucous membranes in general, offer comparatively little resistance, because they contain so large a percentage of saline solutions. Saline solutions conduct better than simple water, and warm saline solutions conduct better than those which are cold.

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* Op. cit., p. 87. † Op. cit., pp. 8–13. ‡ Op. cit., pp. 90–91.

§ Pereira, Food and Diet, Am. ed., p. 39.

The human body, as a whole, conducts electricity ***fifteen to twenty*** times better than pure cold water, provided the skin is thoroughly moistened. It owes this superior conductibility to the *warm saline* solutions which it contains. According to recent experiments of Richardson, the blood is the best conducting material of the body.

Compared with a number of metallic substances the human body is an exceedingly poor conductor. Thus copper is several thousand million times a better conductor than the human body. It should never be forgotten that the epidermis, in a dry state, is a poor conductor. In practice this resistance of the epidermis is overcome by thoroughly moistening it. The hair and nails are also poor conductors. In making applications to the top of the head it is necessary to thoroughly moisten the hair.

Judging from the sensations of the operator when applying a current to a patient through his own person, the nerves and the nerve filaments are better conductors than the muscles, although the experiments of Professor Eckhard seem to point to the reverse conclusion. According to this observer, the resistance of the muscles is 1; of the cartilages 2; of the nerves 2, 1; of the bones 19. In other words, the muscles conduct twice as well as the cartilages, and twenty times better than the bones.

The fact that bones are comparatively poor conductors does not make it impossible or even difficult to pass the current through the bony covering of the brain and spinal cord. It is a mistake, however, to judge of the conductibility of the tissues of the body on purely physical principles; the *living body may conduct much better than the dead subject.* ***Thus the bones of the living body are supplied with blood-vessels filled with blood, and therefore must conduct much better than the dead and dried bones which are subjected to chemical analysis.***

Soft parts which are thus enclosed in a bony covering are less powerfully affected than soft parts which are not so enclosed. The stomach and intestines are more readily affected by pressing the electrode firmly over the abdomen, and bringing the peritonæum and organs into coaptation, than are the brain and spinal cord by applications on the head or spine. Young persons conduct better than the aged; and the conducting power varies in different individuals and in the same individual at different times.

XVI.—*When the electric current is applied over the whole surface of the body, as in general electrization, it passes through or directly affects all the superficial and many of the deep muscles and nerves, and also most of the important organs.*

The electric current always takes the shortest and most direct course from one pole to the other, provided the media intervening between the electrodes is of a uniform conductibility. When, therefore, the positive electrode is applied to one part of the body, and the negative to the other, the current would diffuse itself uniformly between the poles, provided the structures of the body were of a uniform conductibility. But, as has been seen, the different parts of the body vary widely in regard to their conductibility,—those which contain a large quantity of saline solutions being good conductors, and *vice versâ*, those which contain a small quantity being poor conductors,—the difference of conductibility between muscle and bone being nearly twenty to one.

The current does not affect all parts alike. The extent to which any part is directly reached when the current is applied over the surface will depend both on its structure and its situation.

Soft parts, which contain a large amount of water, like the brain, spinal cord, and abdominal viscera, are good conductors, and unless their situation is unfavorable, they are directly and powerfully affected by the current, when applied to the surface by means of moist conductors. On the other hand, bone, which contains a much less percentage of water than the muscles and soft parts, is comparatively a poor conductor. Accordingly, soft parts which are partially or entirely enclosed by bone are much less readily affected by external applications than would be the case if they were exposed.

The electric current, when applied over the head directly, affects the brain and spinal cord. This is proved by practical experience in pathological cases, and by experiments on the dead subject. In some cases of disease of the brain, the pain of applications over the head is so sensitively felt in the brain, that very great caution must be exercised. This phenomenon is sometimes observed in apoplexy. On the other hand, in certain morbid conditions of the brain, sensitiveness becomes so much diminished that a powerful current may be applied on the head without producing pain. Just what morbid conditions of the brain are most likely to make that organ abnormally sensitive or insensitive to the current it is impossible to state with definiteness. From what we know of the effect of morbid conditions of other parts and organs upon the electrical sensibility, it is probably fair to infer that the electro-sensibility of the brain is increased or diminished by the same morbid conditions that modify its sensibility against other irritations. In cerebral effusions sometimes very powerful applications may be made over the head without causing any unpleasant sensation.

On the other hand, in many cases of nervous disease, as dyspepsia, insomnia, and neuralgia, the head, especially on the top, is so exceedingly sensitive to the electric currents that even gentle applications with the hand as an electrode cannot be borne. That the pain thus experienced is not superficial, is proved by the consciousness of the patients. It is deep-seated, and when continued for any length of time is exceedingly prostrating. In cases of softening of the brain, it has been noticed that applications even of the faradic current over the head produced spasms and tremors of the upper and lower limbs.

When the spinal cord is in a condition of health, a powerful current may be applied down the back without discomfort, but in cases of myelitis, spinal congestion, and other morbid states, very marked and peculiar symptoms are sometimes observed. We have seen a case of myelitis when even a very mild faradic current over the spine, near the supposed seat of the disease, caused severe pain in the right leg that continued for several hours. Such a phenomenon is never observed in health. The fact that it does occur, especially when the electrodes are not placed near any prominent nerves, shows very clearly that the current affects the spinal cord in a more direct way than by mere reflex action.

The *results* of *treatment* of diseases of the brain and spinal cord by electrization of the head and back show that the current must affect these organs. As will be described more fully in the sections on general and localized electrization, the results of applications both of the faradic and the galvanic currents to the head and down the back, in diseases of the brain and spine, are in many cases of disease exceedingly favorable, even when no other portion of the body is treated.

Direct Experiments on the Dead Subject.—Dr. W. Erb, in his well-known experiments, sawed off a piece of bone from the skull of a human body, removed the skin and periosteum, and after the bone that had been exposed had become dried, he took out a portion of the brain, and in the cavity thus formed placed the sciatic nerve of a preparation of a frog so that it touched the substance of the brain. He then directed a galvanic current through the head from ear to ear, and also from the chin to the occiput. Contractions were produced in the frog-preparation, showing that the currents passed to the portion of the nerve in contact with the brain. The same result was produced by the faradic current. By substantially the same process, Dr. Erb showed that the currents passed through the spinal cord when applied to the back.

It is worthy of remark, that these experimental results were obtained with comparatively mild currents.

It must be admitted, however, that experiments on the cadaver cannot be as satisfactory as the results of practical experience in the treatment of disease. We do not now know—perhaps may never know—just wherein consists the difference between life and death. We know only in part the chemical changes that take place during the process of dissolution, and cannot, of course, determine with exactness the extent to which they modify the electro-conductibility of the tissues.

It should be stated on the other hand, that Dr. Bonnefin, a pupil of Brown-Séquard, by experiments on the dead subject, arrived at very different results from those of Erb. His experiments were, we believe, performed with only the faradic current.*

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* Brown-Séquard informed us that these experiments were performed under his own eye.

But experiments on the dead subject, whatever may be their results, cannot, for reasons above presented, be as thoroughly convincing as practical experience in pathological cases. The evidence of a large number of patients in regard to the sensations produced by applications over the head and back, and the observations of the physician in regard to the variation of sensibility with the conditions and stages of disease, furnish more satisfactory conclusions on this question than even the most carefully conducted experiments on the dead subject.

It is also clinically demonstrated that the sympathetic system is directly affected by the electric current when the applications are made all over the surface of the back. Our knowledge of the functions of the sympathetic system is at present so incomplete, that we are, perhaps, hardly justified in asserting with positiveness how far the decided improvement in nutrition that follows general electrization is due to the direct influence of the current on the system; but assuming that the opinion commonly held concerning the influence of the sympathetic over nutrition is sound, there is little room for doubt that this influence is very materially aided by electrization on the surface of the trunk. The sympathetic is directly influenced when one of the electrodes is applied on the whole length of the spine, by the anterior border of the sterno-cleido-mastoid muscle, on the head and over the abdomen. There is little doubt that nearly all the ganglia of the sympathetic—those of the head, the neck, the thorax, and the abdomen—are more or less directly affected by the current when it is applied over the entire surface of the body in general electrization. It would seem, indeed, that the sympathetic system would be easier influenced than the cerebro-spinal, from the fact that it is not, like the cerebro-spinal, enclosed by bone, though to a certain extent protected by it.

The very decided, and sometimes very extraordinary tonic results that come from general electrization, can hardly be accounted for on any other theory than that the sympathetic system throughout is directly influenced.

This theory finds its confirmation in experiments that have been made with localized electrization of the cervical ganglia, as will be described in detail under Electro-therapeutics.

That the stomach, liver, spleen, intestines, kidneys, and the genital apparatus, in both sexes, are directly affected by the current in general electrization, is fully demonstrated by clinical observation. The sensations of the patient during treatment, the evidence of pathological cases, and the results of treatment, both temporary and permanent, all unite in furnishing conclusive evidence that these organs are reached by the current.

The walls of the abdomen are so yielding, that the soft parts beneath can, by sufficient pressure, be brought nearly or quite into coaptation, so as to make a good pathway for the current through organs largely composed of water. Illustrative cases will be detailed in the appropriate sections.

On the other hand, the walls of the thorax being composed partly of bone, and being somewhat firm, do not furnish as good a conducting medium, and therefore the lungs and heart are less affected in general electrization than the organs of the abdomen.

XVII.—*Electricity and life are not identical.*

Experiments in electro-physiology, interesting and suggestive as they are, and important as they have been shown to be for therapeutics, have done but little toward solving the mystery of life.

The extravagant hopes at one time entertained that electricity and life would be proved to be identical, have not as yet been realized; but recent investigations, so far as they go, seem to prove that they are radically and essentially different. The facts and arguments on which the theory of the non-identity of electricity and nervous force rests are mainly these:—

1. The nerve-current can be detected in a nerve after it has ceased to react to the electrical stimulus. The reverse of this law, however, does not obtain.

2. The slow rate at which nervous force travels. According to the experiments of Helmholtz and Schleske with the chronograph, the velocity of the nervous force in man is 97.5 feet a second, which is less than that of the greyhound or race-horse.

By means of the noematochrograph it has been ascertained that the brain is $\frac{1}{25}$ of a second in recognizing an impression, and $\frac{1}{28}$ of a second in telegraphing that an impression has been received.

By means of the same instrument it has been ascertained that the brain is $\frac{1}{20}$ of a second in distinguishing and signalling the difference between two colors, and about the same time in distinguishing between two vowels as they are uttered.

As compared with light and electricity, nervous force is exceedingly slow. The velocity of light is over 10,000,000 times, and of electricity over 15,000,000 times, that of nervous force.

It has also been ascertained, by comparative experiments, that the velocity of muscular contraction of the muscles is about $\frac{1}{30}$ of that of nervous force.

The velocity of the nervous force is still further lessened by the action of the curare poison.

3. Ligature or division of a nerve impedes the transmission of nervous force; which would not be the case if the nerves were simply telegraph wires. Even if the stumps of a divided nerve are made to touch each other, the nervous force will not pass.

The relation of electricity and magnetism to life may perhaps be explained by the theory of the Correlation and Conservation of Forces. May not the body contain a number of distinct forces—electricity, magnetism, and vital or nervous force, or life? If light, and heat, and motion, and electricity are mutually convertible, may not the *nervous* force also be convertible with electricity and magnetism? It is certainly probable that the therapeutic results of electrization are partly due to the increase of the nervous force by the molecular changes produced by the action of the current on the tissues.

The subject of free electricity in the body has at various times attracted the attention of observers. Hemmer, in 1790, Gardini, in 1793, made a large number of experiments with a view to ascertain the general electrical condition of the human body. Their conclusions were that there is electricity in the body, sometimes positive, sometimes negative—that it was variously modified by conditions of health and disease. In 2,422 trials on himself, Hemmer found a positive charge 1,252 times, a negative 771 times, and none at all 399 times. He concluded that the natural electricity of the body was positive; that this was modified by physical or mental exertion. Sfösten, in 1800, Ahrens and Pfaff, in 1812, and Nasse, in 1834, investigated the same subject, and concluded that free electricity was more manifest in the enthusiastic and excitable than the cold and phlegmatic, that it was greatest in the evening, that it was increased by stimulants, and diminished by cold. Ahrens and Pfaff stated that the electricity of the body disappeared during attacks of rheumatism, and reappeared on recovery. Nasse found positive electricity in every one, under all circumstances. Although some of these experiments were performed on naked patients, seated on an insulated stool, yet Sterneberg decided that these manifestations of electricity which they obtained were the result of the friction of the clothes on the skin.

Animal Magnetism.—Of the familiar and mysterious phenomena of animal magnetism, so called, our knowledge is at present so unsatisfactory that an attempt to explain them must be futile. The connection that is supposed to exist between animal electricity and animal magnetism is not demonstrated by any known facts. The exceedingly mysterious and suggestive character of the phenomena which appear to be connected with some unknown force in the body has induced a spirit of inquiry, which, in lieu of positive knowledge, has been obliged to content itself with speculations. The most noteworthy treatise on this subject is that of Reichenbach,* in which the author accounts for the strange phenomena attributed to animal magnetism by the existence of *odyllic* (all-penetrating) *force*, which he claims to have first discovered.

The excitement produced on the first publication of the work has now died away, and the science is now waiting for more accurate investigations to provide suitable data before attempting any further speculations on this dark and difficult question.

Electricity in Plants and Fruits.—Electrical currents have been found in pears, apples, peaches, and plums. It has been ascertained by Donnè and Du Bois-Reymond that in apples and pears the currents flow from the peduncle to the bud, but in fruits with stones, as peaches, apricots, and plums, from the bud to the peduncle. When the fruit is divided in a line at right angles with the long axis, and the juice is squeezed out of the two halves in vessels connected with a galvanometer, then on completing the circuit the current is observed.

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* Physico-Physiological Researches on the Dynamics of Magnetism, Electricity, Light, &c.

According to Buff, "the roots and all parts of the interior of plants filled with sap are constantly negative, whereas, on the contrary, the humid or moistened interior of the green twigs, leaves, flowers, and fruit are in a state of permanent positive electrification." Experiments recently made show that in lemons, turnips, gooseberries, and pears, and in cold boiled potatoes, the current is from the skin to the centre; in raw potatoes, the current is from the centre to the skin.

The result of experiments to stimulate the growth of plants by electricity has not thus far been successful.

The animal system, in health as well as in disease, would seem to be variously influenced by the condition and variations of *Atmospheric Electricity.*

The facts and experiments on this subject have been so meagre and unsatisfactory that scientific men have very naturally held their opinion in suspense concerning it; but sufficient evidence is now collected to make it at least probable that the constitution, especially of the nervous and sensitive, is very appreciably and traceably influenced by the variations in the quantity and quality of the free electricity in the surrounding air.

In the first place, there would appear to be a kind of correspondence between the sensation and health of nervous and sensitive constitutions, and the established regular and irregular variations in the quantity and quality of atmospheric electricity. It has been shown that there are two daily tides of positive atmospheric electricity—the high tides between 9 and 12 A.M., and between 6 and 9 P.M.; the low tides between 2 and 5 P.M., and 1 and 5 A.M.* The annual variations are fully as marked as the diurnal; the quantity of positive atmospheric electricity being greatest in the winter, least in the summer, gradually increasing in the fall, and as gradually decreasing in the spring, bearing a pretty constant relation to the temperature. Now it is a matter of common observation that impressible nervous organizations—except the tuberculous—are usually stronger and healthier in the winter than in the summer—are invigorated by the advancing coolness of autumn, and enervated by the increasing mildness of spring. Impressible organizations also observe that they can work better with the brain in the morning than in the afternoon, and that next to the morning the early evening is most congenial to study. These variations in feeling are of course largely dependent on variations in temperature, and it is impossible to distinguish just how much they are related to conditions of atmospheric electricity. Between 1 and 4, the season of the low tide of positive atmospheric electricity, is the hour when many, even those who dine late in the day, are disposed to slumber. These correspondences would seem not to be wholly fanciful, nor fully explicable on other grounds, though their exact relation to conditions of atmospheric electricity may never be precisely demonstrated.

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* Dr. A. Wislizenus, in Transactions of St. Louis Academy of Medicine. Also, Ferguson's Electricity, p. 100.

The correspondence between the irregular variations in atmospheric electricity and the sensations involved in nervous organizations seems to rest on more definite evidence. Thus Dr. Wislizenus found that "in 2,124 observations, made at the regular hours, the atmospheric electricity was 2,046 times positive, and only 78 times negative." Of the 78 times, 30 were connected with thunder or hail storms, or by thunder and lightning; 23 by common rains, and 20 by high winds and gales, without rain, thunder, or lightning; 4 by snow, and 1 by fog.* It seems, therefore, that the chief cause of a condition of negative atmospheric electricity is storm, and especially thunder-storms, and that at all other times positive atmospheric electricity prevails. In very many cases this change to negative electricity takes place shortly before the storm approaches; during its progress there may be—especially in thunder storms—rapidly repeated alternations of positive and negative conditions, followed by an equilibrium, or by positive electricity. Now it is a well-recognized fact that many individuals, just before storms, suffer exacerbations of rheumatic or neuralgic pains. Just before and during storms, corns and bunions, and old ulcers, often become painful. Nervous patients not unfrequently are so unpleasantly affected in their general sensations by the approach of a storm that they can be depended on with considerable certainty as prophets of the weather. The extreme fear of lightning —amounting almost to a monomania—that some experience to a most distressing extent, may possibly be accounted for by the depression resulting from the negative atmospheric electricity.

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* Op. cit., pp. 9, 10.

Dr. Wislizenus also found that snowing and fog were usually accompanied by an increase of positive electricity; this observation is of interest, because it accords with the fact that the approach of snow-storms and the presence of simple fog do not cause the exacerbations of rheumatic and neuralgic pains that are experienced on the approach of storms of rain or thunder and lightning.

In connection with this subject the effects of strokes of lightning are of interest. It is believed that lightning kills either by a shock to the nervous system, or by asphyxia, through violent contraction of the muscles of respiration. Richardson supposes that "sudden expansion of the gaseous part, or atmosphere of the blood, combined in extreme degrees of shock with a sudden conversion of animal fluid from the fluid into the gaseous condition," is the cause of death in such cases. The appearances, on post-mortem examination, are congestion of the membranes of the brain, of the viscera, and muscles of the abdomen. Extreme rigidity of the muscles is often observed after death by lightning. Strange chemical effects may be produced by lightning, even where it does not destroy life. It has been known to cover the teeth and gums with a bitter deposit, and bring out blisters on the body, with an offensive odor, and actual incineration or congelation. It may also cause blindness, paralysis and deafness, and other nervous affections. After death putrefaction takes place early, and cases have been recorded where the bodies became almost liquid before they could be buried. Bodies struck dead by lightning may retain electricity for some time ; instances are recorded where violent shocks have been given from such bodies to those who attempted to handle them.* Authentic cases are recorded where the living human body has given sparks and shocks, like a Leyden jar. Dr. Horsford, of New Hampshire, reported in Silliman's Journal, 1838, p. 394, a case of a lady who, during the prevalence of a very remarkable aurora, became suddenly charged with electricity. She gave sparks to every conductor that she touched, and could charge four persons at once, so that the last could give a spark to a metallic conductor. She continued in this condition for several months, until, under hygienic and medical treatment, the strange phenomena disappeared.† The attention of the medical world has been recently called to the case of a wonderful electrical child in France, that gave shocks to those who entered the room, and from the head of which remarkable luminous appearances were observed.

Lightning may very rarely cure as well as kill. A very few authentic cases are reported of immediate cure of paralysis, and one of deafness, by this heroic remedy.‡

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* Thunder and Lightning, W. De Fonvielle, edited by Phipson, p. 118.

† Morgan, op. cit., p. 196.

‡ Vide Althaus, op. cit., p. 350; also De Fonvielle, op. cit., p. 259, et. seq.

ELECTRO-THERAPEUTICS.

CHAPTER I.

HISTORY OF ELECTRO-THERAPEUTICS.

THE earliest history of electro-therapeutics, as of many other departments of medicine, is shrouded in obscurity. It dates back to a mythical and legendary age, before mankind had been trained to habits of scientific criticism, while yet history was a mass of traditions, and rumor was a substitute for truth.

It is said that centuries ago the negresses of West Africa were accustomed to dip their sick children in water where lay the electric fish called the torpedo. Scribonius Largus, a physician of the time of Tiberius, was accustomed to prescribe the same remedy in the treatment of gout. The remedial powers of electricity were also referred to by Pliny and Dioscorides.

The mysterious power of the magnet was known to the ancient world, but we have no reason to believe that it was ever extensively resorted to by them for the cure of disease. In Europe, during the middle ages, the loadstone was used in the treatment of disease, and although its successes were trifling it aroused the professional attention and received extravagant praise from the distinguished Paracelsus. About the middle of the eighteenth century, Maximilian Hehl, of Vienna, and others, excited a new and more successful interest in the use of magnetism in disease by the manufacture and employment of artificial magnets.

The real history of electro-therapeutics may be divided into *three eras:* the *Era of Statical Electricity*, including the early and crude experiments with the frictional machines and the Leyden jar; the *Era of Galvanization*, beginning with the publication of the discovery of Galvani, in 1791, and including the invention and medical employment of the voltaic pile; the *Era of Faradization*, beginning with the discovery of induction, in 1831–32, and including all that has since been accomplished in the department of localized and general electrization.

In the first era only statical electricity was used, because it was the only form that was known; in the second era, both statical electricity and galvanism were used, since the latter supplemented but not entirely supplanted the former; in the third era, all three forms of electricity, statical, galvanic, and faradic, were brought into requisition, though the use of statical is confined to a few, and will probably soon become historic.

The Era of Statical Electricity.—The records of this era, though not extensive, are yet both interesting and suggestive. It is probable that in this and in the second era very much was attempted and even accomplished in this department that has never been recorded in permanent medical literature, and therefore could never become of value to science.

In 1730, Etienne Grey observed divergence of the hairs in an isolated subject put in communication with static electricity.

The same experiment was repeated by Abbé Nollet and Du Fay. Du Fay observed the electric sparks from the isolated subject.

In 1743, Kruger d'Helmstadt suggested that these electric sparks might be made of service in therapeutics.

In 1744, Kratzenstein, a German physician, recorded a case of cure of paralysis of the fingers by sparks drawn from a frictional apparatus.

In 1746, the discovery of the properties of the Leyden jar by Muschenbroek gave physicians a new means of using electricity in the treatment of disease.

In 1749, Jallabert,* of Geneva, published a treatise on the medical use of electricity, in which he reported a cure of long-standing paralysis of the right arm, resulting from injury by electric sparks. The cure was brought about in two or three months, and may perhaps be regarded as the first decided and unquestioned result of the kind that was obtained in the early days of electro-therapeutics.

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* Experiences sur Electricité. Paris. 1747.

In 1750, Nebel showed that contraction of the muscular tissue was produced by electrization of the tissue.

Bohadtch of Bohemia also recommended electricity, especially for the treatment of hemiplegia.

In 1753, Lindhult, a Swedish physician, reported a cure of epilepsy by electricity. (Mém. de l'Acad. de Suède, vol. XI.)

In 1755, De Häen reported a large number of electrical cures of paralysis, spasmodic and other nervous affections, and also of suppression of the menses, and St. Guy's dance. About this time, also, Schaeffer and Nebel published cures of rheumatism, toothache, hypochondria, paralysis of the optic nerve, and of intermittent fever and neuralgic pains. Between 1750 and 1757 cures of paralysis were reported by Brydone, Bertholon, Sauvages of Montpelier, and Spry, the latter of whom cured a case of lockjaw and paralysis.

In 1763, Watson cured a case of general tetanus in a young girl of seven years. Although the fame of the cures wrought by electricity attracted crowds of invalids, yet by the ignorant and superstitious it was confounded with witchcraft, and the aid of the priest was invoked to save them from its baneful influence.*

Abbé Sans published a work on the medical use of electricity, and recorded important cures. According to this authority, there were seven different methods ot employing static electricity—"an electric bath, drawing sparks, by irroration, friction, insufflation, exhaustion, and commotion." Injurious and negative as well as favorable results were sometimes reported. Thus, Dr. Hart brought on paralysis in a girl, and Abbé Mazras excited epilepsy in one of his patients. Benjamin Franklin failed to cure the invalids that flocked to him after his great discovery, and Abbé Nollet, after many years' experience, was compelled to admit that he had seen but little permanent benefit from electricity.

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* A Treatise on Medical Electricity, theoretical and practical, by J. Althaus, M.D. 1870, p. 284.

In 1773 and 1778, Maduyt presented memoirs (* †) on the subject, in which he affirmed in his report that electricity was a remedy of vast and varied powers; that it had a positive and very beneficial influence over nutrition; and that it equalized the circulation, materially affected the pulse, the perspiration, and the secretions; and was surprisingly efficacious in the treatment not only of paralysis, but also of other conditions, such as constipation and œdema. This report aroused considerable interest in electro-therapeutics on the part of the profession, and for a season the application of statical electricity became extensively popular. In 1777, Cavallo published a work ‡ which excited considerable attention. He reported cures of epilepsy, paralysis, chorea, deafness, blindness, rheumatism, glandular enlargements, and recommended electricity as a means of artificial respiration.

On the theory that medical substances might be combined with electricity, Pivati, of Venice, placed in his electric machine a glass cylinder, fitted with Peruvian balsam, and Giuseppe Bruni affirmed that, by the same arrangement, filled with purgatives, he had produced the same effect on an electrified patient as though the remedy had been administered internally.§

In 1783, Wilkinson presented the results of some experiments with electricity in England. Although the fame of the cures wrought by the new remedy attracted thousands of the people, yet by the ignorant and superstitious electricity was confounded with evil.‖

Of the seven methods of employing statical electricity recommended by these early experimenters, but three were in common

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[*] Mem. sur les effets généraux, la nature et l'usage du fluide électrique considéré comme médicament. Lu en décembre, 1778, à la Société royale de médecine.

[†] Mém. sur les différentes manières d'administrer l'électricité, et observations sur les effets que ces divers moyens ont produits. Lu en décembre, 1783, à la Société royale de médecine.

[‡] A Complete Treatise on Electricity, in theory and practice, with original experiments. Londres, 1777. Id., Medical Electricity. Londres, 1780.

[§] Althaus, op. cit., p. 287.

[‖] A Tripier, Manuel d'électro-thérapie, exposé pratique et critique des applications médicales et chirurgicales de l'électricité. Paris, 1860.

use. These were, the *electric bath, electrization by sparks, and shocks from the Leyden jar.*

The Era of Galvanization.—Animal electricity was discovered by Galvani in 1786 and made public in 1791. It was by the experiments of Galvani that Volta was stimulated to investigate the subject of electricity. He denied the existence of animal electricity which Galvani had discovered. One of the most important fruits of the discussion that arose between them and their respective followers was the construction of the voltaic pile, which for many years physicians employed, with various alternations of failure and success, in the treatment of disease.

In the period intervening between the discovery of animal electricity by Galvani, and the construction of the pile of Volta, electricity was applied to the body by means of metallic plates, joined together by a metallic arc. Sometimes these were simply placed against the skin, and sometimes over spots denuded by a blister.*

In 1792, Behrend, Creve, and Klein suggested the use of galvanism as a means of distinguishing real from apparent death. The first attempts to make galvanism of practical service in the treatment of disease were made by Professor Loder of Jena. The results of his experiments were unsatisfactory.

In 1793, Hufeland and Reil advised the use of galvanism in paralysis.

In 1796, Pfaff advised the same remedy for amaurosis. None of these authorities spoke from much personal experience.†

In 1797, Alexander Von Humboldt‡ suggested, on theoretical grounds, the use of galvanism in paralysis, rheumatic pains, and diseases of the eyes.

Valli actually restored to life, by galvanism, frogs and fowls that had been nearly suffocated.§

The voltaic pile, invented in 1800, marked an era in the medical use of the galvanic current, because, with all its imperfections, it was vastly superior, for therapeutic purposes, to the metallic plates that had previously been employed during the period which had elapsed since the discovery of Galvani. It was at once employed by Loder in Jena, by Grapengiesser,* Bischoff, and Lichtenstein, in Berlin, and by Haller in Paris, chiefly in cases of paralysis.

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* Tripier, op. cit., p. 262.

† Tripier, op. cit., p. 263.

‡ Versuch über die gereizte Muskel und Nervenfaser. Berlin, 1797.

§ Expérience sur le galvanisme, traduit par Jadelot. Paris, 1799.

In 1801, Augustin, of Berlin, published a treatise on galvanism, in which he reported results of treatment of paralysis by applying the negative pole to the central end of the nerve, and the positive to the peripheral. Prof. Schwab experimented with the voltaic pile in cases of deaf-muteism. In 1802 Sigaud de la Fond published a work in which he recommended static electricity for nearly every form of disease. In 1804 Aldini, a pupil of Galvani, published a treatise on galvanism, in which he theoretically recommended it for deafness, insanity, and amaurosis, and also to produce artificial respiration.†

Even during this era, and for many years after the invention of the voltaic pile, frictional electricity was still employed.

In 1817, Dr. Thomas Brown, of Albany, published a work entitled "*The Ethereal Physician*," in which he recommended frictional electricity for paralysis, tic-douloureux, epilepsy, chorea, and in a large variety of disorders.

In 1818, Dr. Everett, of New York, published something on the use of electricity in medicine that was based on experience that he had derived with the apparatus of Dr. Brown.

In spite of all these endeavors on the part of scientific men to give importance and dignity to the cause of electro-therapeutics, it failed to fulfil the extravagant expectations that had been formed of it; a reaction followed, and it fell into disrepute. Electricity had been tried for a wide range of diseases, but partly on account of the inconstancy of the voltaic pile and partly through the ignorance of the operators, it was found to be a most uncertain remedy. It was confounded with mesmerism, which at this period came into notoriety, and for a time it shared its fate.

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* Versuche den Galvanismus zur Heilung einiger Krankheiten anzuwenden. Berlin, 1801.

† Essai théorique et expérimental sur le galvanisme. 1804.

In 1825, Sarlandière proposed the employment of acupuncture needles in galvanization, so that the current could be more exclusively and definitely localized on the desired nerve or organ. This method of treatment was called electro-puncture.* He used for this purpose frictional electricity. Subsequently Magendie successfully experimented with galvano-puncture in neuralgia, paralysis, and other nervous diseases.

The discovery of electro-puncture was the beginning of the science of electro-surgery, a department which at that time commanded a wider interest than the medical use of electricity, and which is now again assuming a most important position in science.

Gerard and Pravaz suggested, and Pétrequin and Ciniselli succeeded in curing aneurism by galvano-puncture. Subsequently galvano-cauterization has been investigated by Steinheil, Middeldorpff (1859), and Amussat and many others. (For detailed history of the surgical uses of electricity, see Electro-Surgery.)

In 1826, Baumé published in London a work on galvanism, which two years later reappeared in a different form, and was translated into French by Fabre Palaprat, who was the first to use the *galvanic* current in electro-puncture.

The Era of Faradization.—The publication of the discovery of inductive electricity by Faraday, in 1831–2, changed the whole course of electro-therapeutics. On the basis of this discovery electric machines were constructed that were both more reliable and more convenient than the ordinary voltaic pile. The first magneto-electric machine was constructed by Pixii in 1832, and was first employed in the treatment of diseases by Neef of Frankfort. Afterwards electro-magnetic (volta-electric) machines were constructed by Neef, Clarke, Stöhrer, Du Bois-Reymond, Duchenne, and others, which from time to time have been variously modified by a large number of experimenters in different countries.

From this time electricity in the form of faradization began to be extensively and indiscriminately employed, both in this country and in Europe. It was used by the laity as well as by the profession, though at first without any recognized method, and without any very clear ideas of the indications for which electrization was adapted. Soon, however, two distinct methods of electrization began to be adopted, in which the galvanic as well as the faradic current have been appropriated, and with one or the other of which may be classed all the applications of faradic or galvanic electricity that have since been employed. These methods are *localized and general electrization.*

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* Mém. sur l'électro-puncture. Paris, 1825.

History of Localized Electrization.—The history of localized electrization is identified with the name of Duchenne, whose experiments and discoveries have given such an impetus to this important and growing department. Prior to the time of Duchenne, faradization had been used by Masson in France, and Neef of Frankfort, and in this country it has been employed by the profession and by the laity from the period of the first popularization of machines of induction.

Even as early as 1843 localized electrization was used in this country side by side with general electrization, though, like the latter, it had received no distinct nomenclature, and was indiscriminately recommended and unscientifically applied.* The two methods, localized and general, were frequently confounded, and both were known under the vague term, "electrifying." Duchenne's earliest attempt to call the attention of the profession to this subject is thus recorded in his own words:—

" De l'art de limiter l'excitation électrique dans les organes sans piquer ni inciser la peau, nouvelle méthode d'électrisation appelée *électrisation localisée*, et dont les principes, résumés dans une note adressée en 1847 à l'Académie des Sciences, ont été développés et publiés dans les *archives générales* de Médecine en juillet et août 1850, et février et mars 1851." In 1855 he published his chief work, " De l'Electrisation Localisée, et de son Application à la Physiologie, à la Pathologie, et à la Thérapeutique."

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* In Pike's Catalogue of Mathematical, Optical, and Philosophical Instruments, 1848, there is a cut of the faradic apparatus that had been in use for five years by these early experimenters. The same work also contains a cut illustrating their method of localized faradization of the leg.

This work became known to the profession in Germany through the abridged translation of Dr. Erdmann.

The leading idea of the method of localized electrization of Duchenne was, that the electric current can be localized over a fixed *point under the skin* if well-moistened conductors are strongly *pressed upon the skin.*

He observed—what is perfectly familiar to all experimenters in electro-therapeutics—that when dry electrodes are applied to the dry skin, sparks with a crackling sound are produced, but no sensation and no muscular contraction. He observed that when the electrodes are well moistened, contractions are excited in the muscles, with the phenomena of sensation.

He recommended three forms of electrodes—solid metallic electrodes, metallic brushes, and the hand.

On these observations and experiments Duchenne based a system of electro-therapeutics and electro-diagnosis which, as since refined, developed, and modified by himself and by numerous other laborers in various countries, has now grown into a permanent department of science.

One of the ablest and most prominent of those whom the writings of Duchenne inspired to enter upon the study of electro-therapeutics was Professor Remak, of Berlin. His first work, "*Ueber Methodische Electrisirung Gelähmter Muskeln*," "On the Methodical Electrization of Paralyzed Muscles," was published in 1855. In this work he revived and recalled the attention of the profession to the *galvanic current*, and he furthermore announced that in order to bring a muscle to complete contraction it is better to excite its motor nerves than to allow the current to operate on the muscular substance itself. His second work "*Galvano-Therapie der Nerven- und Muskel-Krankeiten* was published in 1858.

Remak became the founder of a school of electro-therapeutists in Germany, as Duchenne had been in France. Their systems, as has been said, differed in two important particulars. Duchenne used the faradic current, making the applications to the muscles; Remak used the galvanic current, making the applications to the motor nerves.

Duchenne declared that the galvanic current was useless for the treatment of disease, while Remak contended that it was the only current that was of any value. Duchenne was unwilling to admit the reality of the discoveries of Remak, and Remak as emphatically rejected the conclusions of Duchenne. Both enforced their statements by the results of experiments, and both appealed to experience.

It is now well recognized by all electro-therapeutists that there was truth on both sides of this interesting controversy—that the galvanic and faradic currents are both of service in the diagnosis and treatment of disease, and that too in more than one mode of application. We now see that if Duchenne was too dogmatic, Remak was too extravagant, but that both of them, by their experiments and labors, were of positive service to science, and made the way easier and safer for those who have since followed them in the department of localized electrization.

Remak, shortly before his death, published a work entitled "*Application du Courant constant au Traitement des Névroses,*" Paris, 1865, which contained the leading ideas of his system, and has been the means of stimulating many other experimenters in this difficult department.

Remak did more than merely introduce the galvanic current to the profession—he discovered and recommended special applications of the current, and suggested the theory of its catalytic action. He was the first to scientifically investigate localized galvanization of the sympathetic, of the brain and spinal cord, and thereby greatly widened the sphere of electro-therapeutics. Although at first his theories were scouted, and his statements discredited, yet since his death they have, in the main, been strikingly confirmed, and are now regarded as accepted facts in science. Even during this last era statical electricity has been by no means laid aside. In 1847, Dr. Golding Bird published very remarkable results obtained in the treatment of amenorrhœa by static electricity, in Guy's Hospital. He made use of a Leyden jar. Statical electricity has been successfully used by Drs. Gull and Clement. It has, for a number of years, been successfully employed by Dr. Radcliffe and others, in the London Hospital for the Paralyzed and Epileptic. Quite recently Prof. Schwanda, of Vienna, has reported suggestive results from statical electricity generated by Holtz's electrophorus machine.

Within the past fifteen years localized electrization has been developed and improved in France, in Germany, in England and America, by a number of very able and laborious men of science. Among the recent authors in this department may be mentioned the names of Meyer,[*] Becquerel,[†] Baierlacher,[‡] Althaus,[§] Tripier,[‖] Rosenthal,[¶] Frommhold,[**] Ziemssen,[††] Garratt,[‡‡] Benedikt,[§§] Brenner.[‖‖]

History of General Electrization.—In general electrization the aim is to bring the whole body under the influence of the current, so far as is possible, by external application.

The origin of general electrization, like that of localized, is somewhat uncertain, since it is difficult to determine how long it was used by the laity before we formally introduced it to the profession. It is certain that both methods have been in popular, and, to a certain extent, in professional use in America, from a period not long subsequent to the popularization of the discovery of induction, certainly a long time before they were introduced to the profession. One of the first—and probably the very first—to employ a form of general electrization was Wm. Miller, of New

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[*] Die Electricität in ihrer Anwendung auf praktische Medicin. Berlin, 1854 and 1868. Translated by Dr. Hammond.

[†] Traité des applications de l'électricité à la Thérapeutique. Paris, 1857.

[‡] Die Inductions-Electricität in physiologisch-therapeutischer Beziehung. Nürnberg, 1857.

[§] A Treatise on Medical Electricity. London, 1859. Second edition of the same, 1870. Galvanism in Paralysis, Neuralgia, etc., 1866.

[‖] Manuel d'Electrothérapie. Paris, 1861.

[¶] Die Electrotherapie, ihre Begründung und Anwendung in der Medizin. Wien, 1865.

[**] Electrotherapie mit besonderer Rücksicht auf Nerven-Krankheiten; vom praktischen Standpunkte skizzirt. Pesth, 1865.

[††] Die Electricität in der Medicin. Berlin, 1866.

[‡‡] Medical Electricity. Philadelphia, 1866.

[§§] Electrotherapie. Wien, 1868.

[‖‖] Untersuchungen und Beobachtungen auf dem Gebiete der Elektrotherapie. Leipzig, 1868 und 1869.

York, who began the empirical use of this system of treatment in 1843. Since that time some form of general electrization has been employed by Sherwood, of New York; Dr. W. Demming, of Portland; Drs. Garratt, Cross, and Guthrie, of Boston; Dr. Wells, of Rochester, N. Y.; Drs. Page and Channing, and by a very large number, both in the profession and out of it, of whose names and special methods but little is known, since they have taken but little pains to establish the treatment on a scientific basis, or to introduce it to the attention of the profession. Many of these practitioners combined localized with general electrization, and some, perhaps the majority, employed the latter exclusively, though with little definiteness or precision. Although, as has been said, some of these early experimenters were educated physicians, the majority were ignorant not only of medicine, but of every other department, and not a few, unfortunately, were as unprincipled as they were ignorant.

Although many of these experimenters were outsiders from the profession, although they had no part nor lot in the realm of science, and although many of them were as devoid of conscience as of intellect, yet we should none the less eagerly seek for and accept whatever of truth they may have stumbled upon or discovered. In the history of science it has often been the fortune of the ignorant and the lowly to hit by chance on some great fact for which the wisdom of the ages has sought in vain. Especially has this been the case in Therapeutics. Truly says Dr. Stillé, "*Nearly every medicine has become a popular remedy before being adopted or even tried by physicians;*"[*] and Pereira declares that "*nux vomica is one of the few remedies the discovery of which is not the effect of mere chance.*"[†]

Impartial history must, we think, record that, before Duchenne and Remak were known on either side of the Atlantic, before our more recent electro-therapeutists had commenced their professional labors or studies, there were in this land not a few empirics who, by some form of general or localized electrization, or both combined, or by methods various and inconsistent, and in spite of their own ignorance or vice, were achieving successes in the treatment of disease by electrization which in certain features even the most advanced physicians of our day have not yet surpassed.

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[*] Therapeutics, vol. 1, p. 31. The same author states that "by far the greater number (of medicines) were first employed in countries which were and are now in a state of scientific ignorance."

[†] Materia Medica, vol. 2, p. 336.

If they did not belong to the chosen ranks of the profession, it is none the less true that the results which they secured were oftentimes such as the ablest leaders in science might well have envied. If their methods were empirical, their empiricism was often justified by its success. If their nomenclature was imperfect and confused, and their diagnosis erroneous, yet their confusion and errors were not a little redeemed by the skill with which they met emergencies when the therapeutist was far more needed than the pathologist or the diagnostician. *The great defect of these empirics was not in their results, which oftentimes were truly remarkable, but in the fact that their ignorance of medicine rendered it impossible for them to intelligently communicate their experience to others, or to make it of any permanent value to science.*

In Europe, so far as we can ascertain from the published writings on the subject, or from our own personal observation, the method of general electrization with the faradic or galvanic current, which we have described, has not been used or recommended, at least by men of science. In 1852, Beckensteiner* suggested the idea of "animalizing" static electricity by passing it through the body of the operator, and making passes over or near the patient.

In 1857, M. Dropsy† de Cracow published a new method of faradization, the *modus operandi* of which consisted in connecting an electrode by two branches on the top of the head and the epigastrium, while the other electrode was connected by four branches with the hands and feet. At each sitting the poles were reversed. In 1858, Seiler* proposed to cure consumption and many other obstinate and incurable diseases by passing a faradic current through two electrodes near to but not over the body of the patient.

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* Etudes sur l'Electricité. Paris, 1859.

† Electrothérapie en application médicale pratique de l'électricité basée sur de nouveaux procédés. Paris, 1857, in 8vo.

In 1863, Gubler † suggested the treatment of conditions of debility by placing both hands and feet in separate basins containing salt water, and passing a faradic current through the body.

Our own attention was called to the subject of general electrization in 1866, and in that and the following year we introduced it to the profession, describing in a very general way its powerful tonic effects and *modus operandi.*

(*N. Y. Medical Record*, 1866–67. *Transactions New York State Medical Society*, 1867. *The Medical Use of Electricity, with special reference to general electrization as a tonic, &c. New York*, 1867.)

The leading ideas which, in these earlier writings, and especially in our monograph on general electrization, we sought to demonstrate and impress were :—

1. That electrization was something more than a mere stimulant —that it was also a tonic of very remarkable efficacy, and as such was indicated in a wide range of diseases associated with debility and impaired nutrition.

2. That these tonic effects could be best obtained by making the applications over the surface of the body with sufficient thoroughness to affect the whole system—in the method we then described, the effects and *modus operandi* of which we had investigated in minute detail.

The name *general electrization*, as descriptive of this method of treatment, was first employed by us and in the writings to which we have referred.

Those who had previously used this method of treatment had failed not only to systematize its various orders of effects, to properly classify it among the remedies, or to present the scientific indications for its use, but also to give it a distinct and expressive nomenclature.

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* Galvanisation par influence. Paris, 1858.

† De l'Electrization générale. Bulletin de Thérapeutique, Dec., 1863.

The progress of electro-therapeutics during the last era has been greatly stimulated by the physiological investigations of Nobili, Marianini, Matteucci, Du Bois-Reymond, Pflüger, and others; and has been indispensably aided by the improvements that have been made in the construction of batteries and electro-magnetic machines. (See Electro-physics.)

A comparative review of the history of electro-therapeutics, and of the present accepted principles of electro-physiology, teaches several important lessons. We see:

1. That many of the important deductions of recent experiments in electro-physiology had been empirically anticipated.

Duchenne discovered that irritation of the skin produced sparks, crackling, and a burning sensation, and that electro-muscular contractility and electro-muscular sensibility were produced by irritation of the nerves and muscles, by experiments on wounded patients; but the electric currents had been used to irritate the skin and produce muscular contractions long before his time. His earliest work on localized electrization was presented to the Academy in 1847, but the electric current from a faradic apparatus had been used in various ways, for the treatment of diseases, many years before, and sparks from frictional apparatus, as has been shown, had been more or less employed by a large number of observers, both in this country and in Europe, for over half a century. Many of these experimenters were empirics in the worst sense of the word; but many of them also, with all their manifest ignorance, were, as has been said, not unfrequently successful in the treatment of disease.

During the last century there have been a large number of experimenters in electro-therapeutics who in all their lives never contributed a line to the literature of the subject, and did little or nothing to encourage or inspire others to prosecute the same studies, and who yet not only achieved most decided therapeutical results, but also empirically anticipated the deductions of the ablest electro-physiologists of our time.

Very many of our so-called discoveries in this, as in so many other branches of science, are but revivifications of ancient theories and practices, refined, modified and developed by modern research.

It is quite recently that it has been established by the observations of ourselves and others in pathological cases, and by the experiments of Erb on the dead subject, that the electric currents, when applied over the head and back, pass through and directly affect the brain and spinal cord; but the theory that they do thus affect the central nervous system had been received for years, and has led to successful results in practice.

The proposition of Du Bois-Reymond, that the electric current, after penetrating the tissues beneath the epidermis, diffuses itself through the tissues in various directions, according to the conductibility of the parts, was probably anticipated at the earliest dawn of electro-therapeutics. It was certainly received and acted upon by numerous experimenters long prior to the elaborate researches of Du Bois-Reymond, and in America, and unquestionably also in Europe, has been for years the empirical basis of electro-therapeutics.

Electro-physiology has but very recently demonstrated that the auditory nerve could react to the galvanic current; yet galvanism, almost from its first discovery, has been used for diseases of the auditory nerve, and in occasional instances with success. So also the recent deductions of physiology concerning the changes of irritability that take place when a nerve is subjected to the action of the galvanic current; and also the laws of current direction have been vaguely and unscientifically anticipated in therapeutics for more than a quarter of a century. Not until the time of Remak was it demonstrated that the sympathetic could be directly affected by external electrization, and yet the sympathetic had been directly affected, for good or ill, by all who had previously made applications of electricity over the head, neck, and spine. Very recently, indeed, has it been demonstrated by physiological experiments that electrization has a marked influence over nutrition, but improvement in nutrition was one of the earliest as it has been one of the most constant effects that have been obtained from electrical applications.

That so many of the recent deductions of physiologists had been anticipated by empirics in no way derogates from the honor and the gratitude that science owes to its latest discoverers.

2. Electro-therapeutics has been in advance of electro-physiology. This inference follows directly from the first. Starting with some electro-physiological assumption, or, more frequently, without any theories whatever, men have blindly and empirically resorted to electricity as a panacea for an immense variety of diseases, and, amid many blunders and absurdities, stumbled on many important results. The truth is, that among the advanced minds of our day the conviction is ever deepening and strengthening that therapeutics is not yet, and may never be, an exact science; that the time may indeed never come when it shall be possible to treat any disease by the rule of three. So profound is our ignorance of the chemical constitution of the body; of the molecular and other changes that incessantly take place in health and disease; of the modifications which these changes undergo by the infinite and varying influences of climate, temperament, diet and mode of life; and so limited and uncertain is our knowledge of the nature and action of medicines, that we may well resign the hope of reducing therapeutics to an exact science to distant generations. The number of those in the profession who will subscribe to the emphatic words of Niemeyer, "It is idle to hope for a time when a medical prescription should be a simple resultant of a computation of known quantities," is rather increasing than diminishing with the advance of science, and the belief is extending that therapeutics is mainly a matter of empiricism; that, while we are waiting and toiling to perfect our knowledge of pathology, and determine its relation to therapeutics, we must not allow our patients to suffer, but should faithfully use those remedies and systems of treatment that experience has recommended.

Such has been the practice of many of our most successful experimenters with electrization. For more than a century diseases of which they knew but little, by electric currents, of which they knew even less, and that too not unfrequently with good results. Duchenne introduced localized electrization with the faradic current in 1847, and Remak published his first essay on the constant galvanic current in 1855, but the faradic current had been locally applied by moistened electrodes many years before, and the use of the constant galvanic current even antedates the discovery of the voltaic pile. Indeed, there is scarcely a disease for which electrization is now employed by modern neurologists in which it had not been used, more or less, during the last century, though usually by methods less scientific and results less uniform than at present. It will be seen that paralysis, neuralgia, chorea, epilepsy, rheumatism, diseases of the eye, ear, indeed nearly all the morbid conditions in which electrization is now of service were treated by electricity, and not unfrequently with success, before the present century.

3. Some of the theories of electricity, electro-physiology, and therapeutics have either failed to be sustained by modern investigation, or have been actually disproved. Thus it is now pretty well established that electricity and nervous force are not identical, but the supposition that there was identity between them inspired and encouraged many of the early experimenters. So also there are a vast number of theories concerning the action of electricity on the body, the relation of the poles, &c., that at present are not regarded. The admission must be made, however, that these erroneous hypotheses sometimes led to experiments producing important therapeutical results.

4. The progress of electro-therapeutics has neither been rapid nor uniform; it has been marked by alternations of eras of extravagant faith and activity, with eras of equally extravagant distrust and neglect. Though often in advance of, and unaided by physiology and pathology, it has been so closely dependent on the mechanical contrivances for generating and controlling the electric current that it has necessarily risen and fallen with the progress of mechanical art, and, to a certain extent, has shared in the fluctuations of electro-physics.

Beginning with the mythical procedures of the Roman physicians with electric fishes, it had long slumbered in the forgetfulness of ages when it was revived in the 18th century by the experiments with frictional electricity, and the great discovery of Galvani. The interest thus aroused by galvanism, and the invention of the voltaic pile, rose to a height of enthusiasm that believed that the problem of therapeutics was solved forever, until from repeated failures and disappointments there ensued a reaction of indifference that for many years was only disturbed by the birth of electro-puncture and by experiments in electro-surgery. The discovery of induction, in 1831–32, and the modern improvements in galvanic batteries, have inaugurated a new revival of electro-therapeutics, in which the enthusiasm of the profession, rendered skeptical by past history, but now convinced by unequivocal demonstration, has been slowly and reluctantly enlisted. This last revival, it is safe to predict, will be as much more extensive and permanent than any of its predecessors, as its growth has been more gradual and more scientific.

Thus, after more than a century of experiment and failure, electro-therapeutics is beginning to realize something of the hopes of its early supporters. The tardy fulfilment of the promises of its youth are due not so much to the prejudice of men of science as to the necessary mechanical difficulties in the way of its employment, and to a want of knowledge of the indications for its use and the method of making the applications. The prejudice of which so much has been said was a natural result of the many failures of electricity, and of the fact that, like many other excellent agents, it was for a time almost exclusively in the hands of charlatans.

The history of electro-therapeutics, with its varied alternations of failure and success, and its ultimate triumph, may not inaptly be compared to the incoming of the tide upon the shore, where, although each successive wave apparently recedes as far as it advances, yet the level of the waters is ever gradually rising, with a force at once sure and irresistible.

CHAPTER II.

DESCRIPTION OF APPARATUS EMPLOYED IN ELECTRO-THERAPEUTICS.

In this chapter we propose to describe only those forms of apparatus which have been proved to be, on the whole, the best for the practical purposes of electro-therapeutics. Since the extended introduction of electricity as a therapeutical agent, and especially since its modern revival, a large variety of apparatus has been devised and recommended, both in Europe and America. To attempt a description of, or even to mention, all these is manifestly unnecessary, inasmuch as students and physicians are only interested to know of those that practical experience has shown to be best adapted for the purposes for which they were designed and which are conveniently accessible.

Those who make an extended use of electricity in the treatment of disease will need apparatus both for the faradic and the galvanic current; for, as will be seen further on, the galvanic current is oftentimes of service where the faradic utterly fails, and may accomplish results in the treatment of disease for which the latter is not indicated.

Apparatus for Faradization.—The faradic apparatus which we exclusively employ and recommend is manufactured by Dr. Jerome Kidder, of this city.

Although most of the results of electrization can be obtained from any one of the many varieties of apparatus that are employed in this country and Europe, and although it is not yet demonstrated that the manner in which the electricity is generated (that is, the form of element employed) has any necessary influence on its therapeutical effects, yet, as a matter of fact, much better and surer results will be obtained from an apparatus which is convenient, reliable, and uniform, than from one which is inconvenient, unreliable, and inconstant.

It is proper to say that, in the comparison of the apparatus, we speak from an extended observation and trial of nearly all the most approved forms that are employed in Germany, France, England, and America. The best foreign apparatus probably is that of Stöhrer.

The electricity in Kidder's apparatus is generated by an ordinary Smee's battery.

Smee's element is represented in the accompanying cut. It is, on the whole, the simplest of all forms of batteries. It is composed of two plates of zinc and one of platinum, or platinized silver, held firmly together by a brass clamp, and acted upon by a solution composed of one part sulphuric acid to from eight to fourteen parts of water. When the element is in action hydrogen escapes from the surface of the platinum.

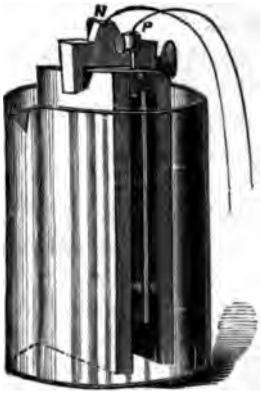

FIG. 24. Smee's Element, used in Kidder's Apparatus. The zinc furnishes negative (N), and the platinum positive (P), electricity.

This is not the only form of element that may be used with Kidder's machine. The zinc and copper battery, acted upon by a solution of sulphate of copper, one ounce to a pint, is frequently employed, and by some is preferred, because it emits no disagreeable gases. It is, however, less neat and reliable than the sulphuric acid element, since, unless the zincs are frequently scraped and cleaned, it refuses to act.

Farmer's thermo-electric battery, that was formerly connected with Kidder's machine, we do not use or recommend. It is heavy, inconvenient, and unreliable.

In cases where a very powerful current is needed an additional battery may be used. The size of this battery that usually accompanies the apparatus is moderate; but in the office a much larger size can be employed if desired.

It is necessary to understand at the outset the distinctions between the terms employed in describing an apparatus for the faradic current.

The *battery* is the zinc and platina in the solution. It is sometimes called the *element* or cell. The *helix* is the coil of wires, boxed, and covered by a movable metallic tube.

The two together constitute the *machine* or *apparatus*. The term battery is very frequently, though incorrectly, applied to the apparatus or machine.

For the physical principles on which this apparatus is constructed, including the philosophy and laws of induction, we refer to the chapter on *electro-physics* (current electricity). Our object here is simply to describe the apparatus in its practical relations.

A very important and distinctive feature of the apparatus of Kidder is the construction of the *rheotome* or current-breaker, which is more readily adjusted than in the majority of apparatuses. It is represented in the accompanying cut, and thus described in the words of the inventor:—

"The following cut represents the vibrating arrangement of one form of my machine. The screw A binds the brass C against the screw B, so as to hold it *moderately firm*, yet allowing its easy adjustment. The iron screw, with its brass head E, should be turned up near the hammer D, when the solution of the battery is weak, but not so near as to allow the hammer to strike this screw when the spring vibrates. The machine works better when the hammer does not strike against the screw. This arrangement affords perfect adjustment of the distance between the hammer and the magnet, without altering the stiffness of the spring. By loosening the nut F, the shaft holding the screw B can be moved so that the platina point of this screw can be located at different points longitudinally on the platinum disc, affording more rapid vibration when this point is moved toward the hammer. The nut F should be turned so as to bind the brass parts firm in their required position.

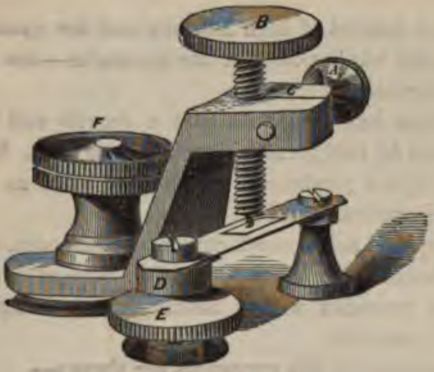

FIG. 25.

"The point of the screw B, which point I make usually of a spiral platinum wire, should barely touch, or press very lightly upon, the platinum plate upon the spring, and when properly adjusted there is seldom occasion to disturb it."

It is the construction of this rheotome, more perhaps than any other single feature, that gives to Kidder's apparatus a marked advantage over all others that have yet been devised.

In many of the ordinary machines the rheotomes are very capricious and unreliable, and their adjustment severely taxes the patience, and not unfrequently has permanently discouraged physicians from making any experiments in electro-therapeutics.

This apparatus has three coils of wire.

A B gives an induced or secondary current of high quantity and low intensity, and also the so-called *extra current*—that is, the current induced by the inner coil on its own windings.

B C gives an induced current of moderate quantity and moderate intensity.

A C combines A B and B C, but does not give the full quantity.

C D gives a current of high intensity and low quantity.

A D gives the whole power of the apparatus—low quantity and high intensity.

The inventor has recently added a *fourth* coil to E, which gives a current of still greater intensity than A D. When applied to the closed eye it produces a glimmering such as does not appear from the application of A D.

The battery and helix, conductors and electrodes, together with a bottle for holding the solution, are all enclosed in a small box, which, when provided with a handle, as it should be, is very conveniently portable.

The advantages of this apparatus are these:—

1. It is simple in its construction and easily managed. Smee's is the simplest of all batteries, and requires but little attention to keep it always in working order.

2. The qualities of current that it affords are better adapted for the various purposes for which the faradic current is employed than those of any other apparatus with which we are acquainted.

We find in practice that for applications to very sensitive parts, A B or A C are preferable to A D.

When the metallic tube is entirely withdrawn A C is stronger than A D.

The difference in the physiological effects of the primary or extra current of the inner thick wire, and the secondary and tertiary currents of the outer and fine wires, is probably twofold: the former may have slight chemical or electrolytic effects, and the latter has the greater intensity.

On taking the electrodes in the hands, A C is felt much more powerfully in the wrists than A D, on account of the fact that it acts more energetically on the contractile muscular fibre. When then it is desired to produce contractions in paralyzed muscle, A C is somewhat preferable to A D.

The superiority of the apparatus is especially apparent in the operations of *general electrization.* As will be seen when we come to explain in detail the *modus operandi* and effects of general electrization, the desired results of this method of treatment can be much better obtained with a soft, smooth current, than with one that is harsh and rough. General electrization is indeed

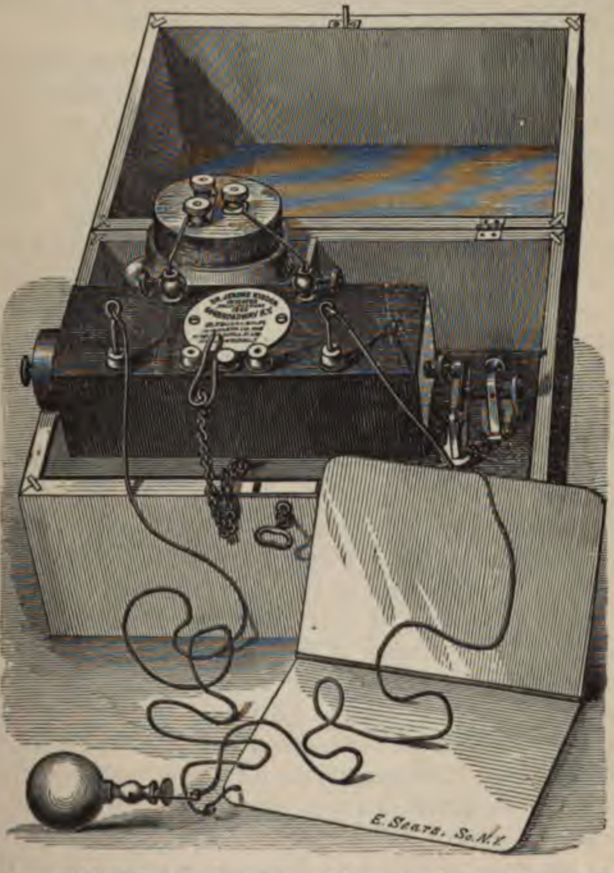
E. Sears. Sc. N.Y.

FIG. 26.—Kidder's Faradic Apparatus, with copper plate and brass ball used in general electrization.

especially indicated and meets with some of its best successes in cases where the predominant symptom is extreme nervousness, but in all such cases the completeness of the success and the rapidity with which it is gained very materially depend on the quality of the current employed.

An ideal faradic current for general electrization in cases of extreme nervousness and irritability, such as is so frequently met with in dyspepsia, hysteria, constitutional neuralgia, and nervous exhaustion, would be exceedingly fine and smooth, and, when properly applied, would be agreeable to the patient. Such a quality of current is supplied by the apparatus here described.

In localized electrization this consideration of quality of current is not so necessary, and yet even here, for conditions of irritation—such as appear in some local neuralgias—the quality of the current used certainly demands attention.

It is needless to say that, in those cases where it is desired simply to produce muscular contractions, currents of a smooth quality are not so essential.

3. *It is reliable.*—A very prominent fault with most of the faradic instruments is uncertainty of action. To meet the wants of the practitioner an apparatus should at all times be ready for action, and should give a current of sufficient power to meet every possible requirement of which the faradic current is capable. The department of electro-therapeutics has been greatly retarded by the uncertainty of the apparatus employed, and the annoying difficulties attendant on their management. A machine that is properly constructed should give a current of at least moderate strength, even when it is not kept absolutely, faultlessly clean. The practitioner may be assured that if a machine requires constant cleaning, watching, and adjusting, there is somewhere a fault or deficiency in its construction.

The apparatus we have been describing is reliable at all times, even when it has been long neglected ; it gives a much stronger current, however, when it is new and clean, when the solution is fresh and strong, and the connecting wires are bright and polished, than when the opposite conditions exist. And yet the overworked practitioner or specialist, for whom it is impossible to keep all portions of the apparatus in perfect order, will not usually be disappointed in its operation, and will find that even with tolerable care it will serve its purpose for many years.

RULES FOR THE USE AND CARE OF THE APPARATUS.

To prepare the Apparatus for Use.—Fill the glass cup with a solution of water and sulphuric acid—one part sulphuric acid to eight or twelve parts water. It is not necessary to be rigidly mathematical in regard to the quantity of the sulphuric acid. The average proportion is one-tenth, but it may range between one-sixth and one-sixteenth.

It is also necessary to put about a teaspoonful of quicksilver in the cup. This touches the lower end of the zincs and keeps them constantly amalgamated. Amalgamation is necessary in order to preserve the zincs from too rapid destruction, and to prevent the branch currents that may arise through the impurities of the zinc. In order to amalgamate zinc, before they have been used, it is necessary to first moisten them with a weak solution of sulphuric acid before pouring on the mercury.

The quicksilver should not be allowed to touch the central plate of platinum, as it may injure it.

The jar should be about two-thirds filled with the solution.

Unite the two pieces of zinc with the platinum between them by means of the brass clamp ; put the element thus formed in the solution. Now unite by a brass wire the top of the clamp with the brass post marked N on the left of the helix. Unite the platinum with the brass post marked P on the right hand of the helix.

In the modified form of apparatus represented in the cut it is necessary to close the prongs between one of the brass posts that is labelled and the one in the middle that has no label. The apparatus is now ready for action. If the spring does not at once vibrate, give it a slight stroke with the finger. If it still refuses to vibrate, it may be necessary to readjust the screw. If the spring vibrates, but irregularly or too slowly, the evil may usually be remedied by readjusting the screw.

Now connect the strings attached to the electrodes with the lettered posts. A is always the positive pole, and B, C, and D are always negative relatively to A. It is always possible to distinguish the negative pole by holding the electrodes for a moment in the two hands; the one in which the current is strongest felt is the negative pole.

If the apparatus refuses to go, or if it stops at any time while in use, the cause may be looked for—

1. *In the screw of the rheotome or current breaker.*—This may not be properly adjusted. The point may be too far from the spring, or too closely pressed upon it. This want of proper adjustment of the screw is the most frequent cause of a stopping of the machine, and of the refusal of the spring to vibrate. The spring may sometimes be corroded at the point where the screw touches it.

2. *In the connection of the wires.* The wires that unite the zincs and platinum may not be properly screwed at their point of connection.

3. *In the battery itself.* The battery—that is, the zinc and platina, with the solution in the glass jar—may get out of order in two ways. *First*, the solution may lose its strength. This difficulty may be remedied either by pouring in some sulphuric acid or making an entirely new solution, or by simply adding more water. *Secondly*, the zincs may become so corroded and incrusted as to become incapable of generating a current. When we have reason to suspect that such is the case we should clean them with an old tooth-brush or cloth, or amalgamate them by first dipping them in the acid solution and then pouring over them a small quantity of mercury. The platinum and the zincs will in time, by hard and long usage, wear out, and will need to be replenished.

4. *In the helix.* It is very rarely indeed that the helix of this apparatus ever becomes so injured as to become incapable of service. If, after we have properly adjusted the screw and spring, made sure of the connections of the wires, replenished the solution and cleaned the zincs, the apparatus persistently refuses to go, we have reason to suspect that something may be wrong with the wires that compose the helix. If such be the case the

evil can be remedied only by the inventor himself, or, at least, by some one practically familiar with the construction of helices. But we should try very patiently and perseveringly before we accept the conclusion that the helix is thus out of order, for it is an accident of extremely rare occurrence.

When no current is felt at the electrodes, although the apparatus acts properly, we know that *the connection is broken somewhere in the insulated conducting wires.* Sometimes the union of the wires with the electrodes is imperfect, and occasionally the wire in some part is broken. It should not be forgotten that the poles can always be distinguished from each other by the fact that when the electrodes are held in the hand *the current is felt most in the negative.* Finally, the electrodes themselves may become very much corroded, and may need cleaning before a good current can be obtained.

To take care of the apparatus.—When not in use, the element can be taken out of the solution and rested on the top of the glass jar, or placed in another jar or cup of water. If the element remains too long a time in the jar an incrustation of salt will sometimes accumulate on the top of the zincs, which will need to be brushed or washed off. This salt is the sulphate of zinc, resulting from the action of the sulphuric acid on the zinc.

It is not, however, absolutely necessary to take the element out of the solution. When properly amalgamated, it may remain in the solution for weeks and months, and yet retain sufficient strength for all practical purposes.

When not in use, the element should always be disconnected with the helix, whether it is kept in the solution or is taken out.

When the element is thus disconnected with the helix, care should be taken that the wires do not touch, for by touching they would make a closed circuit, and action would take place in the battery. We may know that action is taking place in the battery when bubbles of hydrogen are rising up by the sides of the zinc.

Methods of modifying the current.—The strength of the current of this machine may be modified in several ways, as follows :

1. It may be modified by withdrawing or pushing in the metallic tube that covers the helix.

When this tube covers the helix an indefinite number of branch currents are induced in it that interfere with the main current and weaken it. In proportion as this is withdrawn, the induction of branch currents, and the consequent interference with the main current, grows less.

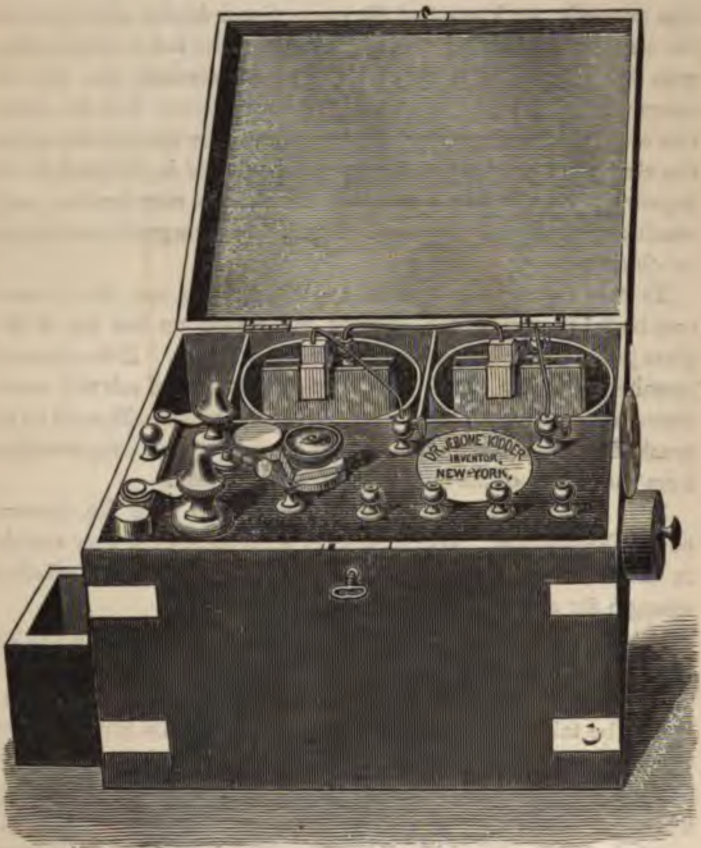

FIG. 27 represents a larger size of Kidder's apparatus. It is provided with a current reversor, by means of which it is possible to change the direction of the current without moving the electrodes or the conducting wires in the posts.

This method of modifying the strength of the current must be used continually both in general and localized electrization.

2. The current may be modified by increasing the quantity of the solution, or of the sulphuric acid in it. This measure can be resorted to when the current fails to accomplish our purpose, even when the metallic tube is entirely or nearly withdrawn.

3. When the current passes through the body of the operator the current may be modified by increasing or diminishing the pressure of the hand on the sponge connected with the positive pole. (See General Electrization.)

The *direction* of the current can be changed, at any time, by reversing the electrodes, or the conducting wires in the posts.

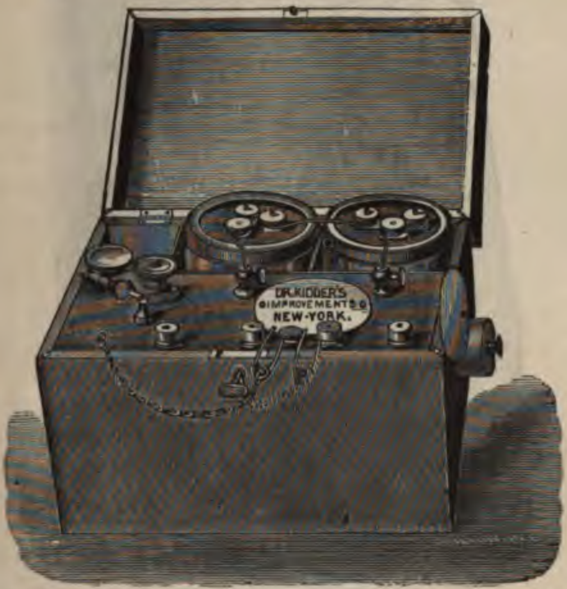

FIG. 28 represents a smaller size of the same apparatus, enclosed in a mahogany case. The helix is the same as that in the ordinary battery. It is more conveniently portable than either of the sizes above mentioned, and furnishes a very good current. Two elements, which are in tightly corked jars, may be united, as represented in the cuts, when a very strong current is desired. The same arrangement can be made with all forms of the apparatus.

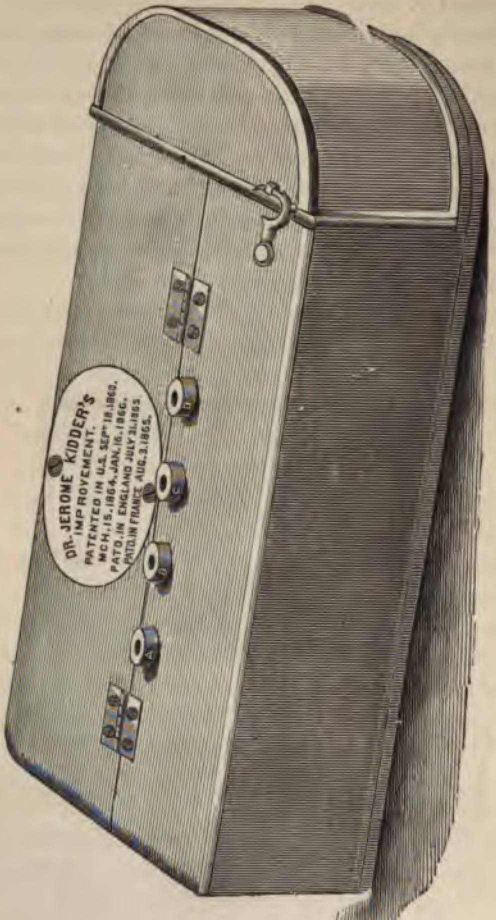
DR. JEROME KIDDER'S
IMPROVEMENT.
PATENTED IN U.S. SEPT 18.1860.
MCH.15.1864. JAN.16.1866.
PATD. IN ENGLAND JULY 31.1865
PATD. IN FRANCE AUG.3.1865.
D
C
B
A

Figure 29 represents a still smaller and more portable form of apparatus. The helix is small, and the element that accompanies the machine and is carried in it, is not more than half the usual size, and consequently the current afforded by the apparatus is not strong enough to meet all the requirements. Its only recommendation is its portability, since it can be carried in the pocket. The solution can also be carried in a flask or kept in the house where the application is made, and can be placed in an ordinary tumbler.

The *magneto-electric* (or so-called *rotary*) machines are not much used at the present day, and are not ordinarily to be recommended.

They have been employed largely and indiscriminately, especially in this country, and have done the cause of electro-therapeutics much evil. Although the current afforded by them is well adapted to produce muscular contractions, having more powerful effect on the sentient nerves and on the retina than the electro-magnetic, and is frequently of service in the treatment of paralysis, rheumatism, and kindred disorders, yet, for all the wide range of diseases in which faradic electricity is indicated, it is neither sufficiently reliable nor sufficiently effective. In most of the conditions of irritability, in which general electrization is most effective, this form of electricity is contra-indicated, on account of the rough and disagreeable quality of the current.

Another very prominent objection to most of the rotary machines in this country is that they require the aid of an assistant to turn the crank. This objection may be met by clock-work attachment. An arrangement of this kind is employed by Dr. Morrell McKenzie, of London, in the treatment of paralysis of the larynx ; but even for this special purpose it would seem to have no advantages, but positive disadvantages, as compared with a compact, convenient, reliable electro-magnetic apparatus described in the preceding pages.

APPARATUS FOR GALVANIZATION.

The want of a suitable apparatus for the galvanic current has been one of the most serious difficulties in the progress of electro-therapeutics. That the therapeutical uses of this current were not sooner investigated, finds in this fact a partial explanation.

The voltaic pile, concerning which such fond hopes were entertained, was soon found to be so inconstant and unreliable, on account of the rapid corrosion of the metals, as to be a very unsatisfactory dependence in therapeutics, and, except by a few, was practically abandoned.

Remak, by means of a modification of Daniell's battery, first succeeded in placing the therapeutic use of the galvanic current on a scientific basis, and since his time apparatuses for generating this current have greatly increased in number and variety. Before Remak, and subsequent to the comparative abandonment of the voltaic pile, electro-therapeutists under the leadership of Duchenne, had experimented almost exclusively with the faradic current, and consequently but little effort had been made to devise a convenient and reliable form of galvanic apparatus.

During the past fifteen years the great efficacy of the galvanic current, and its decided superiority to the faradic in certain conditions of disease, have been so conclusively demonstrated that electro-therapeutists and manufacturers of instruments have combined their forces to improve the galvanic apparatuses.

The ideal aimed at has been to devise an apparatus for the galvanic current that shall possess sufficient electro-motive force, and shall be as *constant*, as *convenient*, as *reliable*, and as *portable* as those employed for the faradic current, and at a reasonable expense. This ideal has not yet been fully realized. Apparatuses there are without number that possess some *one* of these qualifications, or perhaps combine two or more of them, but an *ideal* apparatus, in which *all* these qualifications should be harmoniously united, is not yet, perhaps may never be, invented.

The battery of Gaiffe, Paris (composed of elements acted upon by bisulphuret of mercury), is as portable as the faradic machine of Kidder, but the current it gives is too deficient both in quantity and intensity to fulfil the requirements of electro-therapeutics. Combinations of ordinary Daniell, Bunsen, and Grove cells, which physicians have been compelled to use, to the number of 40, 50, 60, or 100, furnish sufficient quantity and intensity of electricity—*when they are in good order;* but they are exceedingly bulky and unsightly, occupy considerable space, and are absolutely non-portable, and what is worse than all, many of them require constant vigilance to keep them clean.

One of the very best stationary batteries, for office or hospital use, is Remak's, composed of a modification of Daniell's elements, by Siemens & Halske. It is manufactured by Krüger & Hirschmann, Berlin. We have tested a number of specimens of these in Berlin, and have found them to be exceedingly reliable. A great advantage possessed by the elements of Siemens & Halske is that the chemical action is so protected that the battery will go for many weeks without being cleaned. The battery is usually composed of 60 elements (which may be enclosed in a case or closet), and is provided with a galvanoscope, to indicate the strength of the current, a contrivance for changing the direction of the current, and also an arrangement by which the operator can at once select the number of cells that he desires to employ. But Remak's battery, with all its excellent modifications, is non-portable, and is therefore to be used only in office or hospital practice.

So many of our patients have been and are in a condition where it is difficult or impossible for them to visit the office—cases where the galvanic current is strongly indicated—that we have from the first thrown our energies into the attempt to devise or procure a galvanic battery that should at least be portable, and of sufficient intensity for therapeutic purposes, even if it did not fulfil the other requirements.

There are two forms of galvanic apparatus that we chiefly use and which are to be variously recommended according to the special purposes required.

A galvanic battery which serves our purpose in the office most excellently, and which, in an emergency, can be taken out, is a modification of Stöhrer's (Dresden), made by L. Drescher of this city.

The elements, 32 in number, are of zinc and carbon; the solution is composed of sulphuric acid, bichromate of potash, and water—all contained in a box 2 feet in length, and 9 inches in breadth. The solution is contained in glass jars, placed in a movable trough, which can be slid up to the elements when required and let down when the battery is not in use. This battery furnishes sufficient electro-motive force, and will go, even when frequently used, for many months, without cleaning. By a simple and easily-adjusted slide, any desired number of elements, from 1 to 32, can be brought to bear on the patient, and with the slide is also connected an arrangement for interrupting the current.

This apparatus, taken all in all—its abundant quantity and intensity, its constancy, its reliability, its simplicity and convenience, and its possible portability—is one of the best galvanic batteries for electro-therapeutic purposes that we have ever seen in any country. If half or two-thirds of the number of elements were employed, or if they were made smaller, the battery could be quite conveniently portable.

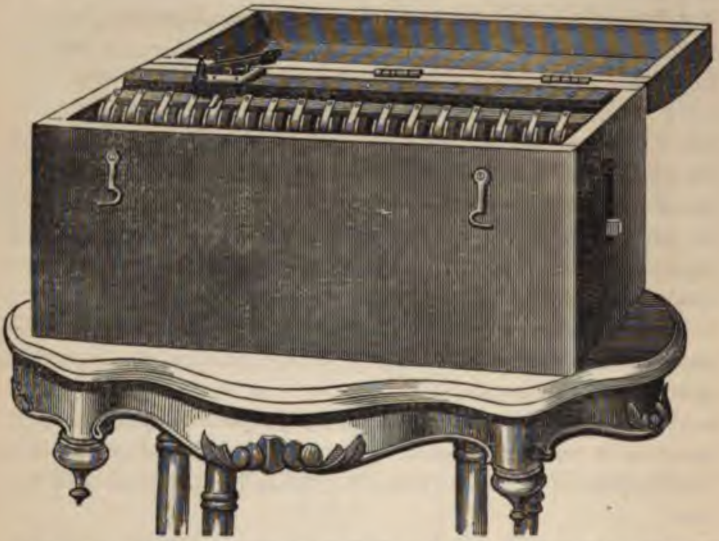

FIG. 30.—Stöhrer's zinc-carbon battery. (In this battery zinc-platinum elements may be substituted for zinc-carbon.)

In this, as in the other galvanic apparatus, the current is felt most intensely at the zinc or negative pole.

We had long urged Jerome Kidder, manufacturer of the faradic machine, to combine Smee's elements in such a way as to furnish a portable galvanic apparatus, and had suggested a variety of ways in which this could be accomplished. He has constructed several forms of compound Smee's battery, all of which are more or less portable, one of which is represented in the cut.*

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* While in London, we were shown, by the courtesy of Dr. Anstie, an ex-

It should be remarked of all these combinations of Smee's cells, that they do not and cannot supply the same *quantity* of electricity that is generated by the cells of Bunsen, Grove, or Daniell.

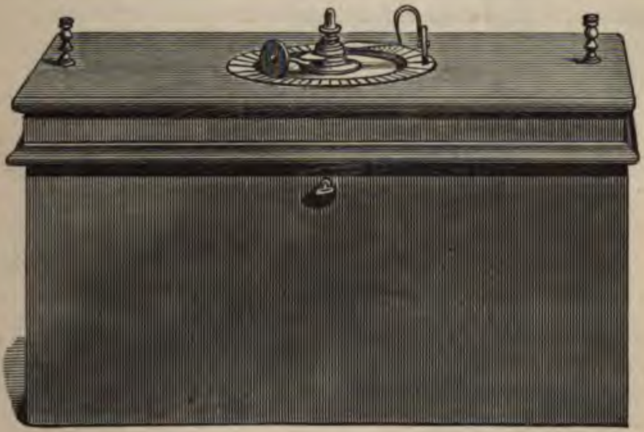

FIG. 31.—Kidder's galvanic apparatus, with box and cover. One of the wheels in the middle of the cover connects any desired number of cells from one upwards; the other wheel *increases* the current without interrupting it. The connecting wires are united to the posts at the ends. Kidder has recently added, at one end of the cover, a current interrupter, and at the other a current reverser. The acid solution may be raised and lowered from the metals, as in Stöhrer's zinc-carbon battery. The apparatus is made of various sizes, from 40 cells to 100, according as it is designed for hospital, or office, or portable use.

Where simple *intensity* is required, Smee's battery is probably as effective as any other form; therefore, for the purpose of producing muscular contractions in paralysis, the batteries just described are as serviceable as those that furnish larger quantity.

When, on the other hand, powerful electrotonic and catalytic effects are desired, as often in applications to the spinal cord, sympathetic, and viscera, and in electro-diagnosis, possibly also

ceedingly neat, convenient, and portable arrangement of 50 Smee's cells, that had just been constructed by Weiss of the Strand. The solution was raised to the plates by a screw, and let down again when the machine was not in use.

in the treatment of some neuralgias, a larger quantity of electricity than can be obtained from Smee's battery may be of service. To settle this question experimentally, however, would require extended comparative clinical experience. Chemical effects of a positive character can be obtained from the combination of Smee's cells above described.

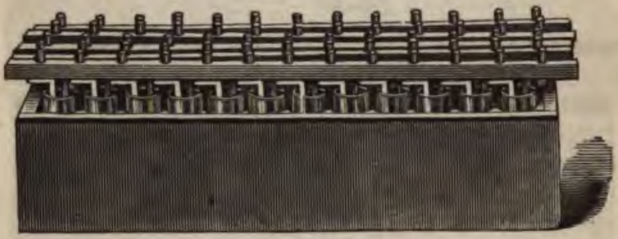

FIG. 32.—Combination of 60 Smee's elements used in Kidder's galvanic apparatus. A much larger size of element is frequently used than the one here represented. Larger elements, which can be more easily cleaned and amalgamated, are frequently kept in the solution all the time without injury. (For directions for taking care of Smee's battery, see p. 127.) It is not ordinarily desirable to have less than 40 large or 60 small elements. If the elements are too small, the current generated will be too weak, unless they are very frequently cleaned and kept in perfect order. This part of the apparatus may be taken out very conveniently, and carried, if it is first provided with some sort of a cover. It is not necessary to take out the box in which it is enclosed.

Benedikt, who uses a portable Smee's battery of 36 cells, also expresses doubt on the question whether different therapeutical results are obtained from large and small elements. Grove's cells are now but little used in electro-therapeutics.

In all these galvanic batteries evaporation takes place more rapidly in warm than in cold weather, and therefore water or the acid solution should be added from time to time.

Belts and Chains.—The use of galvanic chains and belts is a revival of and improvement on the methods of using galvanism that were employed in the period intervening between the discovery of Galvani and the invention of the voltaic pile.

Pulvermacher's belts have been recently modified and improved, and are one of the best forms of galvanic chain or belt that has yet been devised, for direct application to the body. They are made of zinc and brass wire, and are constructed of various shapes and sizes. When moistened with a solution of vinegar and water, and properly applied to any part of the surface of the body, as the neck or trunk, they generate a very feeble current. The *electric disks* of Dr. Garratt generate a feeble galvanic current that certainly acts on the surface over which it is applied.

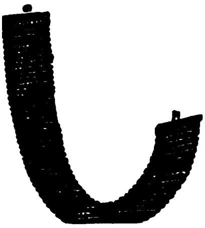

FIG. 33.
Pulvermacher's chain.

Other contrivances for direct and prolonged application to the body are the galvanic poultices of Récamier, the galvanic belts of Bréton Frères, and Prudhomme. The therapeutical value of any of these contrivances is not very great; clinical evidence of very important therapeutic results, or of such as cannot be obtained by galvanization or faradization, is yet wanting, although in some cases they seem to be of some little service in neuralgia and rheumatism. It should be borne in mind that the therapeutic effects of electricity are usually obtained by comparatively short applications, made at intervals of several hours or days, and not by a continuous action of the current. A prominent objection to the wearing of these belts, disks, girdles, etc., is that they sometimes cause ulcers and sloughs that leave permanent cicatrices. (See chapter on Myalgia and Neuralgia.)

The *galvanic chains* (Fig. 33) of Pulvermacher are also used for the purpose of localized galvanization. They are made of wires of copper and zinc coiled on wood, and set in action by vinegar. They furnish a current of considerable intensity and very small quantity, but are unreliable and inconvenient; though they give a very good current when they are of a sufficiently large size, and are in perfect order. They are not to be recommended, except to those who can get nothing better.

Electrodes and accompanying Apparatus.—The electrodes that

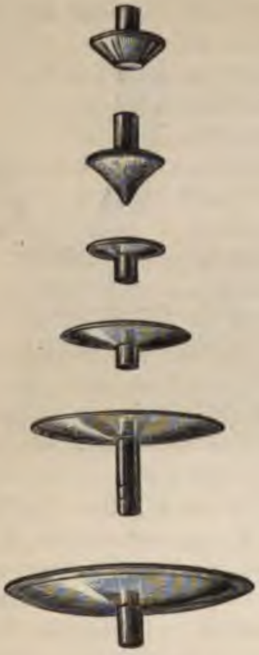

FIG. 34.

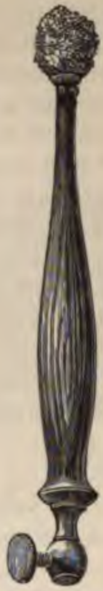

FIG. 37.

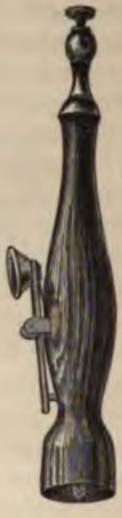

FIG. 35.

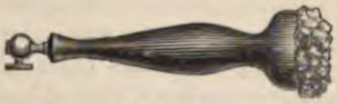

FIG. 36.

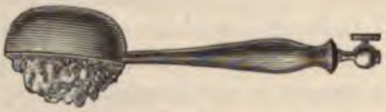

FIG. 38.

FIG. 34.—Metallic electrodes, of various sizes, for faradization and galvanization. FIG. 35.—Universal electrode handle, with ivory interrupter: this is fitted to all the sizes of electrodes in Fig. 34: A sponge is placed over the electrode, which is screwed to the handle so as to hold the sponge firmly. FIG. 36.—Electrode with sponge—average size. FIG. 37.—Sponge electrode with long handle. FIG. 38.—Spinal electrode for applications beneath the clothing.

are needed for local applications to special parts, as the eye, the ear, larynx, œsophagus, rectum, vagina, uterus, bladder, urethra, and so forth, will be described in the chapters devoted to the electrical treatment of these organs. We propose here to represent and describe only those that are of general use in all the ordinary applications, both of general and localized electrization.

The variety of shapes and modifications that may be given to electrodes is limited only by the taste, inclinations, and peculiarities of the operator. In describing those that we chiefly use and recommend, we do not desire to give the impression that we regard them as better than have been or may be devised by others; but simply that they have satisfactorily answered our purposes, and will, we believe, in the main be satisfactory to others.

In the operations of general electrization, we use the *brass ball*, *large sponges*, and *copper plate*, which will be described in the chapter devoted to that subject.

The cuts accompanying represent a general form of electrodes that we have devised for many of the purposes of localized electrization. They can be used for stable or labile currents. The handle, Fig. 35, to which is made to fit a variety of electrodes of different sizes, is provided with an interrupter of ivory, by means of which it is possible to interrupt the current slowly or rapidly, as may be desired, without removing either electrode. This is a very decided advantage, especially in the treatment of paralysis. These electrodes may be covered with soft sponge, flannel, or chamois. We usually employ sponge.

The sponges should be frequently washed in pure water and soap, or in a very dilute solution of carbolic acid or chloride of lime or permanganate of potash, and the sponges should be frequently changed, and when they become of a green color should be replaced. The electrodes should be frequently cleaned; the positive pole especially becomes rapidly oxidized.

Unpolarizable Electrodes.—It is well known to electro-physiologists that in consequence of the electrolytic changes that take place during the passage of a current from the electrodes to the body, a change takes place at the surface of the electrodes, by which a new electrical action is set up that to a certain extent interferes with the main current and also causes pain. Electrodes thus affected are called polarized.

Dr. Hitzig [*] of Berlin has devised electrodes in which this secondary electrical action at the surface does not take place; to these he has given the name *unpolarizable* electrodes. These are made unpolarizable by a solution of sulphate of zinc. By the courtesy of Dr. Hitzig we were enabled to test them while in Berlin, and were favorably impressed with their action. The pain produced by stable galvanization is sometimes very disagreeable, and by these electrodes it was certainly diminished. They can be used several hours without exhibiting any polarization. The subject of unpolarizable electrodes had previously received the attention of Regnauld, Matteucci, and Du Bois-Reymond.

The conducting wires connecting the electrodes with the apparatus are covered with silk; they may be still further insulated by flexible rubber. Many electro-therapeutists have rubber coverings of a different color for the two poles, thus affording a ready means of distinguishing them. An objection to rubber is that the sulphuric acid which it contains corrodes the wires.

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[*] Ueber die Anwendung unpolarisirbarer Electroden in der Electrotherapie. Berliner Klinische Wochenschrift, 1867, No. 89.

CHAPTER III.

GENERAL THERAPEUTICAL EFFECT OF ELECTRIZATION.

The leading therapeutical effect of electrization is that of a stimulating tonic. The propriety of classifying this agent among the tonics as well as among the stimulants is derived from its observed effects over nutrition, especially when it is applied in such a way as to affect the whole system.

It is necessary to state, at the outset, that in defining electrization to be a stimulating *tonic* we use the words in the sense in which they are ordinarily understood and employed when applied to other remedies and systems of treatment, and without any reference to the mere verbal distinctions that may be or have been made in the classification of materia medica.

Stimulants are usually understood to be those agents which *quickly excite* the system, and *temporarily* arouse its activity. They are like the goad, which forces the exhausted beast to draw the burden but does nothing to increase his strength; or like the blast of the furnace, which increases the combustion but adds no fuel.

Tonics, on the other hand, are ordinarily understood to be those agents which *gradually* improve nutrition, restore enfeebled functions, invigorate the system, and *permanently* increase its capacity for labor.

They not only excite into activity the strength that already exists, but they *permanently increase* the strength. They are like the grain which feeds the hungry beast, and supplies the waste of the muscles, or like the wood and the coal which add fuel to the flame.

It is because electrization is capable of producing at once the effects which are ascribed to both these classes of agents, that we have defined it a stimulating tonic. It will be found, on comparison, that it is followed by the leading effects that are commonly attributed to iron, quinine, strychnine, phosphorus, physical exercise, the shower-bath, and other familiar tonic remedies and systems of treatment.

Reasoning from analogy, as well as from experience, it would seem that the full effects of electrization on the human body could only be obtained by making the applications *all over the person.* The influence of any drug or remedial agent on the constitution can only be ascertained by bringing the *whole system* under that influence. A man who habitually washes one of his fingers in cold water appreciates the tonic effects of the cold only in that finger; but a man who habitually takes a shower-bath, or plunges into a tub of cold water, realizes powerful tonic effects on his entire system. If a man daily exposes one arm to the sunlight, while the rest of the body is enclosed in a dark cell, he receives direct tonic effects only in the exposed member; but he who walks forth and exposes his whole person to the solar rays will in time experience the full tonic effect of sunlight on his system. If one hand or one foot is vigorously and regularly exercised, the muscles of that limb exhibit the tonic effects of the exercise, and increase in hardness and perhaps in size; but if all the portions of the body are vigorously and regularly exercised, all the principal muscles will increase in firmness and perhaps in size, and tonic effects will be appreciated by the entire system.

Just so with all other tonic remedies and influences. If quinine, strychnine, iron, arsenic, oil, &c., could be localized in a single limb, only that limb would be directly influenced by them. Their tonic effect is only obtained by administering them in such a way that they will penetrate every portion of the body.

Electrization is no exception to this law. In order to ascertain its full effects on the system at large, and to determine its position among remedies, the applications must be made in such a way that the whole system shall, so far as possible, be brought under its influence. We claim that this is best accomplished by the method of *general electrization* that is hereafter to be explained in detail.

In making a detailed comparison, therefore, between the effects of electrization and the effects of recognized tonics—quinine, iron, strychnine, physical exercise, sunlight, cold bathing, &c.—it is logically necessary that the applications should be so given that the whole body should be brought under the direct influence of the current, just as it is brought under the influence of other recognized tonics as ordinarily administered.

The immediate or primary effects of electrization are often stimulating. The immediate effects of an application of general electrization are often a feeling of enlivenment and exhilaration, drowsiness, temporary relief of pain, and increased warmth of the body.

The same effects are notably observed after the shower-bath, a tumble in the surf, a brisk walk in the open air, or from the administration of alcohol. When given in an overdose, or to those who from serious organic disease or other causes are peculiarly susceptible to general electrization, it may produce temporary faintness, weariness, and even a cold perspiration. In the same class of patients, overdoses of exercise, bathing, &c., will produce the same unpleasant effects.

General electrization reduces the pulse when it is too high, and raises it when it is sluggish.

Agents which are classed as stimulants often have a decided *sedative* or *calming* effect.

That the judicious administration of alcohol in fevers has the effect of lowering the pulse is now generally conceded, and this effect is watched for as an evidence that the patient is improved by stimulation.

The bath, or a walk or other form of muscular exercise, judiciously used, lowers the pulse when it has been excited by anxiety or overwork, and raises it when it is already slower than is normal.

An application of general electrization frequently sharpens the appetite, and makes the sleep for the night sounder and more refreshing. The latter effect may result from localized electrization of the head, spine, or cervical sympathetic.

These temporarily *calming*, *soothing*, or sedative effects of electrization, which were first pointed out and emphatically insisted on by us in all of our earliest writings on electro-therapeutics,* and which were naturally and properly received with doubt by those who had no opportunity of testing their truth, have recently been confirmed by Legros and Onimus, in a variety of pathological cases. The facts which we have cited demonstrate fully that, far from being always an excitant, the current of the pile, as has been maintained by Hiffelsheim, may become a *sedative* or *calmant.*† Many of our remedies that are classified as stimulants or stimulating tonics do the same.

Like other stimulating tonics, general electrization, when given in an overdose, or in too great strength for the constitution of the patient or the condition of the system at the time, may be followed by secondary or reactive effects that are both disagreeable and positively alarming.

The second or third day after an injudicious application the patient, especially at the outset of treatment, may experience soreness in the muscles, an indefinable feeling of nervous exhaustion, irregularity of pulse, and sometimes exacerbation of special symptoms. It is well known that severe physical exercise will produce all these unpleasant secondary effects, especially in patients who are feeble and unaccustomed to muscular exertion. A cold bath, either in the surf or at home, that is too prolonged may give rise to all these symptoms the night or day following. Unpleasant effects may secondarily follow an overdose of our ordinary stimulants, as alcohol, or from internal tonics, as iron, quinine, strychnine.

The permanent effects of general electrization are as closely analogous to those which come from other tonic remedies and systems of treatment as are the immediate and secondary effects.

The very marked permanent effect of general electrization is improvement in the sleep. Physical exercise,—walking, boating, gymnastics, bowling,—cold bathing, and the ordinary internal tonics do the same, though not so markedly and with far less uniformity.

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* New York Medical Record, Dec. 15, 1866; The Medical Use of Electricity. New York: 1867. Transactions of New York State Medical Society, 1867. Introduction to Tobold's Chronic Diseases of the Larynx. 1868.

† Legros and Onimus, op. cit., p. 39. These authors, however, make a capital error when they deny the same qualities to the faradic current, and imply that it is injurious to the brain. See also Meyer's Electricity in its Relation to Practical Medicine, op. cit., p. 93.

General electrization also permanently improves the appetite and digestive capacity, and regulates the bowels. Improvement in the various operations of digestion is one of the most uniform effects of our ordinary tonics, and it is for that purpose, more perhaps than for any other, that they are employed.

Like other tonics, general electrization often permanently relieves neuralgic pain. The various forms and localizations of neuralgia and neuralgic symptoms,—headache, tic-douloureux, as well as pains in the trunk and limbs,—when they are not dependent on some incurable lesion or condition, are frequently dispelled permanently by this method of treatment. Cold bathing, sunlight, exercise, quinine, iron, strychnine, arsenic, and cod-liver oil, all notably produce the same effects.

Like other tonics, general electrization equalizes the circulation. This effect, when it *immediately* follows an application, is merely the *temporary* excitement, similar to what follows a rapid walk, or gymnastics, or alcoholic stimulants, and soon passes away. But when it becomes a permanent condition —when the patient feels less annoyance from chilliness and cold extremities—it is a resultant of the improvement in nutrition.

Like other tonics, also, general electrization directly affects the brain and sympathetic system, and thus often relieves mental depression. Severe phases of hypochondriasis—even those which are just on the verge of insanity—are frequently held in check, and sometimes thoroughly dispelled, by a long and persistent use of this remedy. This same condition is combated by travelling, physical exercise, bathing, and internal tonics, and with more or less success.

Like other tonic measures—gymnastics, active games, and outdoor amusements, &c., &c.—general electrization causes the muscles to develop in size and hardness, and sometimes, though by no means uniformly, causes important and rapid increase in the weight of the body, the result of the improvement in nutrition. Increase in weight is familiarly observed after a trip of pleasure, a vacation in the country, a voyage by sea, and very frequently indeed from the use of cod-liver oil and strychnine. General electrization sometimes causes the patient to increase in weight from the very outset of the treatment, and to an extent that is most surprising.

Like other tonics, general electrization, in its ultimate effects, increases the disposition and the capacity for labor of the brain or of the muscles. This is indeed the chief end to which all tonic treatment is directed, inasmuch as diminished capacity for labor is perhaps the condition for which tonics are most frequently advised. General electrization does not usually increase the capacity for toil until it has first improved the sleep, the appetite, the digestion. The same is true of many other, if not all, tonic remedies. Lastly, experience shows that general electrization is usually contraindicated in those diseases and for those temperaments that will not bear internal tonics. We find almost invariably that it must be used most cautiously, and meets with its worst failures in cases when quinine, strychnine, iron and stimulants have proved to be injurious.

Although the experiments of Legros, Onimus, and others (see page 83) were performed with the galvanic current, yet it is by no means demonstrated that important though less marked chemical as well as physical effects are not producible by the faradic current.

Becquerel allows that the laws concerning the direction of the current, in the treatment of neuralgia at least, apply to the faradic current.*

This question, however, like all other questions of electro-therapeutics, must be settled by clinical experience, rather than by even the most skilfully conducted experiments on animals.

Whatever difference of opinion there may be concerning the rationale of electrization, or whatever dispute there may be concerning the use and the meaning of the words stimulant and tonics, the majority of advanced practical electro-therapeutists must substantially endorse the emphatic words of Prof. Niemeyer: "*In the constant current we have a means more powerful than any other of modifying the nutritive conditions of parts that are deeply situated.*"*

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* Legros and Onimus, op. cit., p. 83.

It should not, however, be forgotten that effects of electrization on nutrition had been obtained by numerous observers for years before they received any scientific explanation, or before even any attempt was made to give them a physiological basis, and that too with the faradic current alone.

Rationale of electrization. Both the stimulating and the tonic effects of electrization are resultants of the various and divers action of the currents on the tissues. These effects have been defined as *mechanical*, *physical*, *catalytic* (increase of circulation and absorption), *electrotonic* (modification of nerve), *electrolytic* (electro-chemical decomposition), and *chemical.* The mechanical effects are most markedly observed from the faradic current, the other effects from the galvanic. These terms, considered as explanations of the action of electrization, are, it must be admitted, quite unsatisfactory, since they are incapable of exact and complete definition, and must, to a certain extent, include each other. It is safe, however, to say that we know as much of the rationale of electrization as of most of our internal remedies. (See effects of the electric currents on the tissues and on nutrition in electro-physiology.)

In the time and manner of their development the tonic effects of general electrization resemble those of other tonics in these *two* particulars :—

1. *They are developed slowly.*—This slowness of development marks a radical distinction between tonics and mere stimulants. The agreeable stimulating effects which immediately follow an application of general electrization, just as they follow the use of gymnastics, walking, active games, &c., soon pass off or merge into the permanent or tonic effects, that come more or less slowly, and after repeated treatment.

2. *They are often developed long after the treatment is abandoned.*—Weeks and months after a patient has taken a course

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* Text-Book of Practical Medicine; Translations of Drs. Humphreys and Hackley, vol. ii., p. 290.

of treatment by general electrization he may continue to improve in his general condition, even though very little progress may have been made while the applications were being received. Just so the tonic effects of a trip by land, of a sea voyage, of our ordinary summer vacations, are sometimes not appreciated until after we have returned home, and are again fully at work.

(The various effects of general electrization will be treated in full detail in the chapter devoted to that subject.)

The inquiry now very naturally arises, why it is that the important fundamental fact—that electrization is a powerful means of improving nutrition, and capable of producing effects on the constitution similar to those which are familiarly obtained from the tonics in every-day use—has until quite recently escaped the observation of the very able writers who in different lands have devoted themselves to electro-therapeutics.

The inquiry is thus answered:—

1. Because most of the recent scientific observers whose writings are authorities in electro-therapeutics have used electricity locally, in some form of "*localized electrization.*"

For obvious reasons, that have already been presented, *localized electrization* must produce chiefly local effects, which although they are *tonic* in their character, so far as they go, and reveal themselves by marked improvement in the local nutrition, would not ordinarily suggest the powerful constitutional tonic powers of which electrization is capable when applied all over the body, any more than the feeble effects of washing the hands, the face, or the feet, or any other single member or organ, would suggest or give any intimation of the well-known constitutional effects of surf-bathing or the shower-bath.

Indirect constitutional tonic effects result from localized electrization of the central nervous system, and especially from galvanization of the sympathetic, although, as will be seen, they are not as marked as those which follow general electrization.

It is a very interesting and significant fact, however, that since the introduction into medical practice of the methods of galvanizing the nervous centres first suggested by Remak, electro-therapeutists have achieved success in a variety of diseases associated with debility and impaired nutrition, where before electrical treatment was supposed not to be indicated, at least by those who confined themselves to localized electrization.* A suggestive fact relating to this subject is that Gubler, who is one of the very few European writers who had used faradization in such a way as to directly affect the whole system, also remarked tonic effects in conditions of debility, even from his very awkward and imperfect method.†

2. Because the immediate effects of electrization are so markedly *stimulating*, as to suggest the idea that it is simply and *only* a stimulant or irritant. In some of the cases for which localized electrization are used the stimulant are the effects which are chiefly desired. But, as has already been shown, many of our ordinary tonics are primarily stimulating, and so much so that they have been classed as *stimulating tonics.*

There is little question that if muscular exercise, sunlight, cold bathing, &c., had been used only locally, as electricity has been used, they might have been regarded merely as stimulants.

3. Because until quite recently most of the recognized authorities and writers on electro-therapeutics of modern days have not used electricity in those diseases and morbid conditions where tonics, *par excellence*, were demanded. They have used the agent mainly with a view to stimulating effects, and in some form of localized electrization. On this principle they have treated paralysis, rheumatism, neuralgia, &c. As we shall demonstrate hereafter, besides those diseases in which the efficacy of localized electrization is fully established, the morbid conditions and symptoms for which electrization is most rapidly and permanently successful, are precisely those in which we use our ordinary tonics—such as dyspepsia, nervous exhaustion, insomnia, hypochondriasis, hysteria, general neuralgia, chorea, spinal irritation, and some forms of paralysis dependent on or associated with general debility.

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* Vide the writings of Remak, Meyer, Benedikt, Niemeyer, above quoted.

† De l'Electrisation générale considérée comme agent tonique et stimulant diffusible. Bulletin de Thérapeutique, Décembre, 1863. (For description of his method, see p. 112.)

Furthermore, in prosecuting this inquiry we must not overlook two important historical facts :—

1. In the latter part of the last century frictional electricity and the current of the voltaic pile were used for a variety of diseases for which we now use tonics, and oftentimes with some success. But the agent was used mostly empirically, without any definite idea of its nature or *rationale* of its operation. Partly on account of the inconstancy and uncertainty of the voltaic pile, and partly on account of the many failures that were necessarily inevitable with such poor apparatus and desultory experience; partly also as a reaction from the extravagant hopes and promises of the earlier experimenters, the system of treatment soon fell into disrepute.

2. Tonic effects have been obtained from various methods of employing electricity by non-professional men—charlatans and outsiders—in the United States at least, for many years, although very few of them have known or suspected the nature of the agent they dealt with, or of the diseases they have treated.

CHAPTER IV.

COMPARATIVE VALUE OF THE GALVANIC AND FARADIC CURRENTS.

SINCE the time of Remak the comparative value of the galvanic and faradic currents in therapeutics has excited continual interest, and at one time was the subject of angry controversy.

At the present day all electro-therapeutists who keep abreast of the progress of their department agree that both currents are of service—that one will fulfil certain conditions for which the other is inadequate, and that no one who expects to secure in practice the complete effects of electrization can dispense with either. Concerning the special indications for the use of one or the other, opinions widely and honestly differ, according to the opportunities and experience of each individual. In Germany, where the school of Remak is dominant, the galvanic is used more than the faradic ; in France, at least among the disciples of Duchenne, the faradic more than the galvanic. In England and America both currents are employed, general practitioners using chiefly, or in the majority of cases entirely, the faradic ; while specialists use both with more or less exclusiveness.

Much of the confusion that exists concerning the differential indications for the use of the galvanic and faradic currents arises from an imperfect or erroneous or exaggerated conception of the distinction in their physiological effects. The general belief or supposition is, that there is between them a radical and important difference in *kind*, as though they were two different agents or forces, and that an appreciation of this distinction is essential for a knowledge of the differential indications for their use.

A fundamental physiological distinction between the currents is that the galvanic, on account of its greater continuousness of action, possesses greater chemical, electrotonic, catalytic, or electrolytic powers. The experiments of Du Bois-Reymond and others and clinical experience have established this question beyond dispute.

Experience shows that chemical effects of a positive character are, however, produced by the faradic current, though they are incomparably less active and less important than those of which the galvanic is capable, since the latter, in sufficient quantity, can efficiently cauterize.

From the accumulating results of experiments and experience in electro-diagnosis and therapeutics, we think that there is strong reason for regarding the essential distinction in the effects of these currents on the body as mainly of *degree*,—practically amounting, it is true, to a difference in kind,—and that this is the scientific basis for their differential employment. Thus the galvanic current, applied on the face and head, produces flashes on the retina, while the faradic will not. But we have treated a number of cases of nervous disease where the same flashes were caused by the faradic. With the improvement in their general condition, this unusual susceptibility to the faradic influence has disappeared. An important peculiarity of the galvanic current is, that when applied on the neck it causes a metallic taste; and yet we have seen a case of constitutional neuralgia, combined with excessive irritability, where the same effect was markedly and even unpleasantly produced by the faradic current when applied to the seventh cervical vertebra. Other well-recognized peculiarities in the effects of the galvanic current, distinguishing it from those of the faradic, are—giddiness and vertigo, when applied on or near the head; redness and burning sensation of the skin at the points on the surface where the electrodes are applied. All of these effects are observed in a less degree from the faradic current; and some of them, in cases of great abnormal sensitiveness, are very decided.

When we come to study their therapeutic effects we also find that both currents differ chiefly in degree. In the form of localized electrization both can produce muscular contractions in paralyzed muscles, and relieve local neuralgias; both cause absorption of abnormal secretions; and both can directly affect the brain, spinal cord, sympathetic, and all the internal organs, producing, in different degrees, the various therapeutic results that directly and indirectly flow from electrical excitation of these parts. In the form of general electrization both currents, besides producing most of the other results of localized electrization, act as powerfully stimulating tonics, and thus form most efficient aids in the relief and cure of nervous exhaustion, nervous dyspepsia, constitutional neuralgia, and of a wide range of nervous diseases associated with or dependent on general debility.

In electro-surgery both currents avail to discuss tumors, heal ulcers, and hasten absorption, although for these purposes the galvanic is frequently much the more effective.

And yet the difference in degree between the effects of the two currents are so marked and so clearly demonstrable as to be practically equivalent in certain instances to a difference in kind, and to give very important and remarkable advantages to one current or the other, according to the indications required.

The advantages of the galvanic over the faradic are :—

1. *A greater power of overcoming resistance.*—It therefore affects the brain, spinal cord, and sympathetic more powerfully than the faradic, since the anatomical position of these parts is such that considerable resistance must be overcome in order to directly affect them. For the same reason it is usually to be preferred when it is desired to affect the middle and internal ear, the retina, and the muscles of the eye.

2. *A power of producing muscular contractions in cases where the faradic fails.*—This peculiarity of the galvanic current has now been observed so frequently, and in such striking instances, that it has become an accepted fact of electro-therapeutical science. Illustrative examples will be given in the section on paralysis. After a certain amount of treatment by the galvanic current the paralyzed muscles frequently resume their susceptibility to the faradic.

3. *A far more potent catalytic, electrotonic, chemical, and thermic action.*—The chemical power of the galvanic current is most markedly seen when used for the purposes of galvano-

cautery or electrolysis. In order to produce the energetic chemical effects of the galvanic current it is necessary to use elements that generate quantity of electricity, and to combine them in such a way that the quantity produced shall be very large, since a large number of elements, arranged for intensity, exhibit only a comparatively feeble cauterizing effect. It is because the galvanic current can be thus arranged for quantity, more than in any difference in *kind* between the effects of the two currents, that gives it its superiority to the faradic, so marked and peculiar as to practically amount to a difference in kind. The quantity of the faradic can be but little increased, and hence, although it does possess some chemical virtues and produces slight chemical effects, it is not indicated where such effects must be very energetic and concentrated. The superior efficacy of the galvanic current to the faradic, so often observed in the treatment of neuralgia, of atrophied muscles, rheumatism, is probably due to its greater "catalytic" and electrotonic action. It probably induces more rapid and more important molecular and other changes in the tissues. This superiority of the galvanic current is supposed to be due to its more continuous duration; it moves constantly in one direction, and thus produces more powerful electrolytic effects than the faradic current can possibly produce, with its rapid interruptions.

The advantages of the faradic over the galvanic current are these :—

1. *By virtue of its frequent interruptions it more easily produces muscular contractions, when passed over the muscles or the nerves that supply them.*—In order to produce full muscular contractions with a galvanic current of moderate strength it is necessary to interrupt the current, and, unless it is quite powerful, to localize at least one of the electrodes over the motor nerve by which the muscle is supplied—that is, over the so-called "motor points." On the contrary, the faradic current is in a condition of rapid interruption and produces contractions when indifferently passed over the surface of the muscle, as well as when localized on the main motor nerve that supplies it.

This advantage of the faradic current is best appreciated in general electrization, the powerful tonic effects of which, as will be seen, are partly and quite largely due to the passive exercise and consequent oxidation and other important changes of tissue that result from the several thousand muscular contractions that take place during an ordinary sitting. In localized electrization this advantage is not so clearly and strongly marked, since in this method, by a proper knowledge of electro-therapeutical anatomy and sufficient care, it is possible to direct one of the electrodes on the "motor points;" and yet even here the faradic current is much more convenient, because its employment requires no arrangement for interruption, and less minuteness of attention to the situation of the motor nerves. The exceptional cases of paralysis where the muscles have lost their susceptibility to the faradic current do not interfere with the general rule.

2. *It produces greater mechanical effects.*—These mechanical effects of the faradic current are due to its rapid interruptions, which cause contractions not only of the muscles, but also of the contractile fibre cells, thus stimulating the circulation, and with it the processes of waste and repair. In this respect its action is similar to that of rubbing, pounding movements and vibrations. These mechanical effects are especially indicated in the treatment of diseases of the abdominal viscera, which are supplied with contractive fibre cells, anæsthesia, and general debility.

3. *It is less likely to produce unpleasant or harmful effects, when incautiously used, than the galvanic.*

To confirm this statement we rest mainly on the evident results of clinical observation.

We may indeed refer to a number of cases of severe constitutional neuralgia and excessive nervous exhaustion where the faradic current invariably relieved, and where the galvanic current as invariably aggravated the symptoms. Our own experience teaches that wherever the galvanic current can be used without injury, there also a faradic current of corresponding intensity will be harmless.

It teaches further, as above stated, that in certain conditions, when properly used, the galvanic current, even when its tension is very slight, may occasion evil results where the faradic is not only harmless but of decided benefit.

In all applications to the head, neck, and spine especially, applications of the galvanic current can rarely be protracted without injury, while in many cases the spine and neck may be faradized through very prolonged sittings, with positive benefit to the patient. To the head, also, a faradic current of a proper quality may be applied much longer than a galvanic current, before unpleasant dizziness or headache is excited. The belief, pretty generally entertained in Europe, that the faradic current cannot be applied to the head without injury, is to be accounted for by the fact that most of the electric machines there employed do not furnish a current of sufficient smoothness for faradization of the head. Most of those who attempt this method of treatment use too small electrodes, and thus give the current greater density than the brain can bear. Galvanization of the eye or ear, or of the cervical sympathetic, must always be shorter than faradization of the same parts. These considerations, however, need not interfere with the use of the galvanic current to these parts, in all cases where it offers a positive advantage over the faradic.

A consideration of some practical importance with general practitioners is, that the faradic apparatus is more convenient, more portable than even the compactest galvanic apparatus that has yet been devised. It is impossible, however, for any practitioner to realize anything like the full benefit of electrization without apparatus for the galvanic as well as the faradic current.

The *general* differential indications for the use of the two currents may be thus summed up. The galvanic should be used—

1. *To act with* SPECIAL ELECTROLYTIC POWER *on the brain, spinal cord, sympathetic, or any part of the central or peripheral nervous system.*

2. *To produce contractions in paralyzed muscles that fail to respond to the faradic.*

3. *In electro-surgery, to produce electrolysis or cauterization.*

The faradic should be used—

1. *To act* MILDLY *on the brain, spinal cord, sympathetic, or any part of the central or peripherical nervous system.*

2. *To excite muscular contractions wherever the muscles are not so much diseased as to be unable to respond to it.*

3. *To produce strong mechanical effects.*

Both are essential in electro-diagnosis—the faradic especially for the muscles, and the galvanic especially for the nervous system; and both are adapted for general as well as localized electrization, although in general electrization the faradic current is chiefly used. It logically follows from what has been said that very many—perhaps the majority—of diseases are best treated not by one current exclusively, but by both currents, either in alternation or succession. Special indications will be given under the special diseases.

GALVANO-FARADIZATION.

In order to secure the advantages of both currents, and at the same time to avoid the trouble and inconvenience of employing them in succession or alternately, as is so frequently necessary, we have devised a method of using them *simultaneously*. To this method we have given a name which sufficiently expresses its character—*galvano-faradization.* It may be either general or localized.

The method of general galvano-faradization requires a double electrode, with one part for the galvanic and the other for the faradic current. The copper plate may be connected at one part with the pole of the faradic, and at another with that of the galvanic apparatus; thus the circuit is completed for both currents.

In localized galvano-faradization it is necessary to have in use two double electrodes; for this purpose the double excitors of Duchenne answer very well. By a proper construction and adjustment of the electrodes it is possible to localize the two currents very near to each other. Whether any special therapeutical advantage arises from the simultaneous use of the two currents we are unable to state.

CHAPTER V.

LOCALIZED ELECTRIZATION.

Principles and Directions.—The object of localized electrization is to confine the direct action of the current to some particular part of the body.

This is accomplished by placing electrodes so that the current, in passing from one to the other, shall chiefly traverse only that particular part that is to be affected.

In this way the current may be localized in a muscle, or group of muscles, in any of the internal organs, in the brain, spinal cord, sympathetic, in a plexus or nerve-tract, or in any part of the central or peripheral nervous system.

It is usually unnecessary and frequently impossible to make the localization either complete or exclusive. Certain hidden and deep-lying muscles can only be reached through other muscles, and in order to affect any of the internal organs it is necessary that the current should also traverse intervening and surrounding tissues.

Again, the action of the galvanic current especially is rarely or never confined to the region between the poles, but, either directly or by reflex action, affects other portions of the body. Thus peripheral applications often affect the brain and spinal cord.

The advocates of localized electrization have been divided into two schools, that are now gradually uniting and must soon merge into one. The French school, under the leadership of Duchenne, use chiefly *peripheral faradization, with a view to exclusively local effects;* the German school, under the leadership of the late Professor Remak, use chiefly *central galvanization, with a view not only to local but also to indirect constitutional effects.*

The advanced German electro-therapeutists at the present day, to a certain extent, use peripheral faradization and galvanization, as well as central galvanization, and thus unite all the advantages of both systems.*

The scientific use either of *galvanization or faradization requires as accurate as possible preliminary diagnosis of the disease.*

The dictum laid down by Benedikt, to make the applications to *the seat of the disease*, is thoroughly philosophical if it be not too exclusively followed, and the very great advantage of central over peripheral electrization is explained by the fact that the majority of nervous diseases are of central and especially of spinal origin. In cases of doubt it is necessary to electrize in succession all the suspected localities until the results of treatment show conclusively that we have hit upon the seat of the disease. Accordingly, in obstinate or doubtful cases the head, the cervical sympathetic, and the spine, and in some instances the uterus or organs of the abdomen, are to be successively electrized. Neuralgia especially, which is much more frequently of central origin than is commonly supposed, usually yields sooner and surer to applications at the seat of the disease than at the seat of the pain.

On the other hand, to entirely neglect peripheral electrization is as narrow and unphilosophical as it would be to exclusively depend upon it. In all central paralyses that are accompanied by loss of electro-muscular contractility or sensibility, or by muscular atrophy, or by simple debility, the progress is very materially aided by peripheral electrization, and very successful results can be obtained by this method alone.

In the very numerous cases of doubt also, when the locality of the disease cannot be ascertained, as well as in conditions of irritation where electrization of the seat of the disease will not be borne, peripheral applications alone are frequently of decided service. For peripheral applications both the galvanic and faradic currents are used ; for central applications, chiefly the galvanic

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* The school of Remak, on the other hand, is gaining ground in France, as we judge from more recent literature, and also from our own personal observations in the cliniques of Paris.

(see p. 156). Statical electricity is now but little used. For method of employing it see chapter on that subject.

Instruments for Localized Electrization.—In localized electrization the same galvanic and faradic apparatus are used as in general electrization. For localized electrization in all its modifications there are needed a variety of electrodes of different shapes and sizes, to reach the various localities and accomplish the different indications.

Of the electrodes there are three general forms—*electric hand; the metallic brush; solid metals and metals covered with sponge, flannel, linen, or chamois*, thoroughly moistened.

Dry or Cutaneous Faradization.—To accomplish dry faradization the portion of the skin over which the application is to be made should be wiped thoroughly dry, or, what is better still, sprinkled with some absorbing powder, as the common nursery powder; and the application may be made with the *dry* hand of the operator, or with metallic electrodes.

In dry faradization with the hand there is heard a peculiar crackling sound, which is caused by the sparks that take place as the current passes from different points of the hand to the skin.

When the dry hand is used, the operator passes the current through his own person, one of the electrodes applied to some near point by an assistant, or held in the hand by the patient himself. Solid metallic electrodes of various shapes may be used for dry electrization.

Dry electrization by the metallic brush is a very painful method of application, and is to be resorted to only in those cases where there is profound cutaneous anæsthesia or in neuralgia. In all cases where there is great sensitiveness the hand is to be preferred to any form of artificial electrodes.

Electric Moxa.—The so-called *electric moxa* is produced by using a metallic brush, one dry metallic, and finely pointed, and one moistened electrode. The dry electrode is rapidly touched to the surface where the moxa is to be made, while the other is kept firmly applied to some near and indifferent point. The surface of the skin should previously be rubbed very dry or sprinkled with some absorbing powder.

The operation requires a current of some intensity, and is exceedingly painful. It is chiefly employed as a counter-irritant in neuralgia, in which affection it is frequently successful. The electric moxa may also be produced by means of two metallic brushes, one of which is pressed on the skin.

Electrization with Moistened Electrodes.—When it is desired to affect the tissues lying beneath the epidermis, it is better to use electrodes covered with sponge, chamois, or flannel, *thoroughly moistened* with salt water or pure water.

The size and shape of the electrode employed must be modified according to the situation and sensitiveness of the part where the current is to be localized, and also by the sensitiveness of the patient. As a rule, small, finely-pointed electrodes are required for localized faradization of single muscles, larger electrodes for large muscles, or groups of muscles, and those with the largest surface for central galvanization.

When the current is localized by means of moistened electrodes, it diffuses itself through the body between the electrodes in various directions. The extent of this diffusion and the directions of the current will be variously modified by the situation of the electrodes and the structure and relation of the parts that lie between them. (See Electro-Physiology, pp. 84–99.) It is manifest also that the density of the current, other conditions being the same, will be greatest near the electrode and least at the farthest point between them. *The strength of the current being the same, small electrodes are more painful than those with a broad surface, and metallic more than the wet sponge or flannel.* The least painful form of artificial electrode is a soft sponge, with a broad surface, and well moistened.

Two general methods of localized electrization are recognized—the *direct and the indirect.* In direct electrization the application is made over the muscle to be excited. In indirect electrization the application is made to the nerve which supplies the muscles. In the former method, large electrodes are preferred; in the latter, usually those which are small and pointed. The faradic current is best indicated for direct electrization, and the galvanic for indirect.

The points where the motor nerves enter the muscles are called "motor points." They have been carefully demonstrated and located by Ziemssen* on the dead subject.

It is not always possible to produce muscular contractions by irritating the points where the motor nerves enter the muscles.

In *stable* applications both electrodes are kept in a fixed position.

In *labile* applications one of the electrodes is moved or glided over the surface; sometimes both of the electrodes are moved simultaneously.

A current is called *continuous* when it is allowed to flow in one direction without interruption. Only the galvanic current can be continuous, since the faradic is always in a condition of interruption.

A current is called *interrupted* when it is broken by removing one of the electrodes, or by some form of current breaker, or by any method of breaking the circuit. The faradic current is always interrupted by its rheotome, but it may be still further interrupted by removing one of the electrodes.

A current is called *uniform* when it remains of the same strength during the applications of the electrodes.

A current is called *increasing* when its strength is gradually augmented during the applications. This method possesses a great advantage in treating conditions of irritation and inflammation. It may be used with both galvanization and faradization.

A much more powerful current can be borne when its strength is *gradually increased* than when it is suddenly let on in full force with the first closure of the circuit, as is usually the custom with the majority of electro-therapeutists. A current which, when suddenly closed, may cause unbearable pain, and, when near the nerve-centres, dizziness and faintness, may oftentimes be borne without discomfort and with positive advantage if it is gradually increased from a very mild current.

Increasing currents are indicated in applications to the brain, sympathetic, spinal cord, the eye and ear, urethra, inflamed joints, and to all conditions of great irritation in any part of the body.

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* Die Electricität in der Medicin,. pp. 154, *et seq.*

The faradic current (of Kidder's apparatus) may be increased by slowly withdrawing the metallic tube. To gradually increase the galvanic current the battery must be so constructed that the elements can be slowly immersed in the liquid. The galvanic current can also be increased by an arrangement that gradually adds to the number of elements without interrupting the current, or, when a sponge electrode is used, by slowly increasing the pressure.

The term *voltaic alternatives* is applied to those applications in which the direction of the current is reversed during the sitting.

For electrization of muscles, labile or stable interrupted currents are preferred. For electrization of the head, spinal cord, sympathetic, and nerve-tracts and plexuses, stable continuous currents are indicated, and these again may be either uniform or increasing.* Labile or stable interrupted currents are best adapted to produce muscular contractions, and cause most potent physical and mechanical effects, while stable continuous currents, whether uniform or increasing, produce the strongest chemical electrolytic or catalytic action.

It has been shown, however, by Matteucci that electrolytic effects attend even an instantaneous passage of the current.

In cases where the electro-muscular contractility is not greatly diminished, it is an advantage to use electrodes with a broad surface, since thereby several motor points may be influenced simultaneously, together with a considerable extent of muscular tissue, and because they are less painful than small electrodes. In such cases the faradic current is preferable.

When the electro-muscular contractility is very greatly diminished, as so frequently happens in paralysis, contractions are best produced by small, finely pointed electrodes, applied at the motor points of the individual muscles; yet even here electrodes of moderate size are usually preferable. Such cases often require the galvanic current.

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* What we here call the *increasing* current Frommhold has designated as "swelling intensity." For this purpose he uses a galvanic apparatus, in which the elements can be slowly dipped into the solution during the application, thus gradually increasing the strength of the current to any extent that may be desired.

We employ the increasing in general as well as in localized electrization, and with the faradic as well as the galvanic current.

In localized electrization of the brain, spinal cord, and sympathetic and nerve plexuses, electrodes with broad surfaces are used, and the galvanic current more than the faradic.

SPECIAL RULES AND DIRECTIONS TO BE OBSERVED IN MAKING THE APPLICATIONS.

Direction of the current and position of the poles.—In localized as in general electrization, the only rules to be observed concerning the direction of the current and position of the poles are those which are derived from *experience.* Electro-physiology has indeed shown that when a nerve is put in the electrotonic condition by the action of the galvanic current, the anelectrotonic region at the positive pole is in a condition of lowered irritability, and the catelectrotonic region at the negative pole is in a condition of increased irritability;* that the ascending current contracts and the descending dilates the blood-vessels;† that the chemical effects at the two poles are essentially different, acids going to the positive and alkalies to the negative;‡ and that there is a certain and definite law of contraction: and yet it must be conceded that these electro-physiological deductions cannot, in the present state of science, be made the basis of electro-therapeutics. So wide and uncertain is the difference between the physiological and the pathological condition of any part of the body, and so meagre and fragmentary is our knowledge of the intimate structure of the human frame, and so absolute our ignorance of the nature of life, that any attempt to build up an *exact system* of electro-therapeutics, based on electro-physiology alone, must inevitably fail. Even though the present conclusions from electro-physiological experiments be accepted as infallible, yet there remain so many unknown and unknowable factors concerning the structure and functions of the human system and the laws of disease, that in practice we are compelled to regard these conclusions as incidental confirmations and interesting suggestions, and not in any sense as guides in making our applications. We believe that among all progressive, advanced, and liberal-minded electro-therapeutists the conviction is gaining ground, that in cases of real or apparent conflict between electro-physiology and experience the former must always yield.

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* See Electro-Physiology, pp. 53–56.

† Legros and Onimus, op. cit., p. 34.

‡ See Electro-Physiology, p. 83.

In regard to the direction of the current, experience shows that important and successful therapeutical results are obtained from both the negative and the positive pole, from the ascending and the descending currents.

The rule is, that the descending current calms, while the ascending irritates; and yet there is no question that both currents may have a calming or an irritating effect, according to the strength of the current used, the length of the application, and the nature and locality of the disease.

Some operators apply the positive pole over the seat of the pain or inflammation, and others the negative; and both obtain good results. Some use the ascending current, others the descending; and both produce satisfactory muscular contractions. In localized galvanization of the brain, cervical sympathetic, and spinal cord, both directions of the current produce therapeutic results.

Concerning the position of the pole and the direction of the current, experience, however, points this general rule, that may in a manner serve to guide us in making the applications, though it should never be blindly followed :—

The positive pole and the descending current are the more calming, the negative pole and ascending current are the more irritating.

Accordingly, in spinal meningitis and myelitis the positive pole is placed over the seat of pain or tenderness, and in peripheral neuralgia dependent on neuritis the descending current is to be preferred to the ascending. On the other hand, anæsthesias and paralysis of motion are best treated by the negative pole and the ascending current.

But this rule is at best a general one. It is open to many exceptions, and is modified by a variety of factors. Whether the effect of an application of electricity is of a calming or irritating character depends on the temperament of the patient, the nature and locality of the disease, and the length and strength of the application, as much as, and oftentimes even more than on the position of the poles or the direction of the current.

Accordingly, the general law we have laid down not only does not always hold, but in some cases appears to be actually reversed.* The result is, that every application of electricity, like every dose of internal medicine, is in a sense an experiment, which must be tested not by *à priori* reasoning, but by its own individual practical results in each individual case. The above law applies, so far as it applies at all, to both the galvanic and the faradic currents. As applied to the faradic current, it may be explained by the fact that that current is felt more strongly at the negative than at the positive pole. As applied to the galvanic current, it may also be partly explained by the established fact of electro-physiology, that the anelectrotonic region at the positive pole is in a condition of lowered irritability, while the catelectrotonic region at the negative pole is in a condition of increased irritability. The *polar* method of treating diseases of the ear by the galvanic current—by which Brenner and Erb have obtained good results—will be described in the chapter devoted to that subject.

We repeat again, that this general law should be followed intelligently, and not blindly; that too many unknown and varying factors enter into electro-therapeutics to make it an exact science.

The *dose* of localized electrization is made up of two factors—the *strength* of the current and the *length* of the *séances*.

Strength of the current.—The strength of the current employed must be so modified by the disease, the locality, the general condition of the patient, that it is manifestly impossible to lay down special rules in regard to it. Even if the dose of electricity could be measured with the same mathematical exactness as drugs, there would yet be room for a large exercise of judgment in the treatment of each case. In localized electrization with the faradic current we must sometimes reduce the current to its minimum, and then again increase it to its maximum. In localized electrization with the galvanic current we must have at command the whole range of elements from one to the highest number of the battery.

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* It was the opinion of Remak, that in catalysis the transference of liquids took place from the positive to the negative pole; and accordingly he advised the use of the positive pole over the seat of inflammation until effusion appeared, when the positive should be reversed. In central applications his rule was to apply the positive pole over the seat of the disease when the inflammation was active, and the negative when it was in a torpid condition.

There is more danger that the currents used will be too strong than too weak. With beginners the tendency is to *overdo* electrization: the very frequent impression that the results will be in direct proportion to the strength of the current that the patient has the nerve to bear, is sure to be dispelled by larger experience. In localized electrization, the rule of caution in this respect is more imperative than in general electrization, because the former method, other conditions being the same, is the more irritating, since the electrodes are placed nearer to each other, and the part or organ to which the application is made receives the effects of both poles; whereas in the latter the body is chiefly under the influence of the positive pole only.

Painful and irritated parts, and the central nervous system, in all conditions should at first be treated with mild, though they may subsequently be effectively treated with powerful currents. The first tentative applications should always be with weak currents, which may be gradually increased according to the results of treatment and the behavior of the patient. Before applying the electrodes to the patient it is always well, even for those who use a galvanometer, to ascertain whether the current is of the proper strength for the purpose desired, by directing it for an instant through the *hand, between the thumb and forefinger.*

Peripheral applications to the muscles, with a view to produce muscular contractions, should be made with a current of *just sufficient strength to excite the contractions;* and no recognizable benefit, and possible harm, may come from increasing its strength very much beyond this point.

Usually nothing is gained and much may be lost by very painful applications.

In localized electrization with small electrodes, some considerable pain is frequently necessary—more than is comfortable to the patient, and more, by considerable, than is required in general electrization, where large and soft sponges are used; but the applications should rarely be made so as to cause very intense or protracted pain. In peripheral applications, where the nerves are not in an irritable condition, little permanent harm may come from severely painful applications, aside from the annoyance of the patient; but in galvanization of the central nervous system serious results—hemorrhage, congestion, and exhaustion—may flow from the use of currents that are disproportionately strong.

A guide which is usually reliable is the *sensitiveness of the patient.* Those who, from anæsthesia or from some constitutional peculiarity, are little sensitive to electricity, may be treated with strong currents; and, *vice versâ*, those who are specially susceptible to electrical irritation should be treated with mild currents. But there are exceptions to this rule both ways. Some hysterical patients need to be put under the influence of an anæsthetic,* and some bear without discomfort a current that has very pernicious effects. In this, as in the other factor that constitutes the dose, each case must be studied by itself.

Length of the sittings.—The *length of the sittings* must be largely determined by the locality and nature of the disease, the condition of the patient, and the strength of the current employed. Applications to the central nervous system, especially with the galvanic current, should be mild, and of short duration. The range of time that experience has shown to be most beneficial is given in the chapter devoted to the details of applications to different parts of the body under the different diseases.

Beginners especially should resist the temptation to prolong the sittings. This caution should especially be heeded when the patient is unaccustomed to the treatment, or whenever the galvanic current is applied to the head, eye, ear, cervical sympathetic, or spine. In peripheral applications greater latitude may be given, but in all cases *it is better to give much too little than a little too much.* Too severe or too prolonged applications may cause unpleasant and even alarming relapses, from which the patients recover only with difficulty.

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* See Benedikt, op. cit., p. 80.

Frequency of the applications.—The frequency of the applications depends on the condition of the patient, the strength of the current employed, the length of the séances, and the progress of the cases. The range is from twice a day to once a week. The average for all cases and in all conditions is once every other day, with occasional intervals of longer duration.

To the rule that the applications of localized electrization should be short, there are some striking exceptions. Both galvanization and faradization may sometimes be protracted for hours without injury and with positive benefit. A patient of ours, on whom we had for several weeks employed stable galvanization for an affection of the eyes, on leaving town obtained a galvanic apparatus of twenty cells of bisulphuret of mercury, which generated a current of fair strength. With this apparatus he began to treat himself, at first for half an hour daily, from time to time increasing the length of séance until he took *four* applications daily of one hour each. His method of application was to place the negative pole over the closed eye, and the positive at the back of the neck. This habit he continued for a number of weeks with decided advantage, and with no unpleasant result beyond the irritation of the skin beneath the electrodes.

Our attention has been called to the case of a patient afflicted with asthma, who found great relief by passing a faradic current through his chest for one, two, or three hours every night.

A medical friend of some experience in electro-therapeutics informs us, that in a case of very great pain attendant on abscess of the thigh, he caused complete relief by applying a very strong current with metallic electrodes directly through the affected part for several hours, after applications of the usual length and strength had failed.

These exceptional cases that have been brought to our attention, taken in connection with the results that sometimes follow the use of galvanic belts, pessaries, etc., suggest the propriety of trying *protracted applications in obstinate cases of disease.*

The law of adaptation of the strength of the current has exceptions both ways. We once treated a medical gentleman by general faradization, and with a current which, though quite strong, was not painfully felt. That same and the following night he experienced symptoms in the cervical spine and arms that clearly indicated congestion of the cord, and for several days caused much alarm lest paralysis might result. It was between the sixth and seventh cervical vertebræ that the current was applied with special power.* This is the only instance of the kind that has ever fallen under our observation, although we are daily accustomed to make strong applications of the faradic current to the same region of the spine. The anomalous result was more noticeable in this case, because the patient, though dyspeptic and nervous, was endowed with a considerable amount of adipose tissue. Probably the cord was predisposed to congestion by a condition of exhaustion. Another fact of interest connected with the same case is, that he was at that very time suffering from orchitis, brought on by a faradization at the hands of a practised electro-therapeutist, and with a current which, though strong, was not painfully felt during the application.

Intervals.—It is not usually of advantage to push the treatment for many months without cessation, unless the applications are made very infrequently. When the patient has been treated every other day, or daily, for one or two months, it is well to allow an interval of from one to four weeks before systematic treatment is renewed. It is often observed that during these intervals patients improve even more rapidly than before.

The *course of treatment* ranges between one treatment and one or two hundred, and the length of time from one day to several years. The majority of the cases in which localized electrization has been found of service are chronic in their character, and can only be permanently relieved by persevering treatment.

The conclusion is, that there is necessity for the continual exercise of judgment; that the strength of the current, the length of the séances, the frequency of the applications, and the time of the treatment must be studiously varied according to the indications of each case.

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* The case is also an interesting illustration of the fact that the faradic current, when applied to the spine, directly affects the cord.

The general maxims to be observed in the use of localized electrization may be thus recapitulated :—

1. The best guide in regard to the strength of the current is the sensitiveness of the patient. Some patients are better conductors* and more sensitive than others who have equal or greater strength of constitution. In occasional instances, the sensitiveness of the patient becomes utterly unreliable. Some patients are subsequently prostrated by applications which at the time were scarcely felt, and others are benefited by a strength of current that is absolutely unbearable without the aid of an anæsthetic.

2. Regard should be had to the age of the patient. Of the two extremes of life, the young bear the electric currents much better than the old. The very aged need to be treated with special caution, while infants in their mothers' arms may bear as strong *peripheral* applications as adults. Adipose tissue is a bad conductor; and, other conditions being the same, corpulent persons can bear stronger currents than the lean. The tolerance of electricity in infants may perhaps be partly explained by this fact.

3. The galvanic current more powerfully affects the nervous system than the faradic. Therefore, other conditions being the same, galvanization should be shorter than faradization.

4. Central applications should be milder, shorter, and in every way more cautious than peripheral. In faradization of muscles, about a minute should be given to each muscle.

5. The time of the sittings ranges between half a minute and ten or fifteen minutes. The shortest applications are made to the head and sympathetic, the longest to the extremities. For the

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* That individuals in health differ very widely in their susceptibility to electricity can be proved by a very familiar experiment. Let a number of persons of equal age join hands in an electric circuit, and it will be found that some are much more powerfully affected than others. The different conductibility of different individuals may perhaps be explained by the difference in the relative quantity of saline solutions of which their bodies are composed.

spine and special organs the time ranges from two to five minutes. In exceptional cases very protracted applications are of service.

6. In regard to frequency, the applications may be made twice a day or once a week, according to the indications and results; the average is three times a week.

7. In protracted cases, intervals of treatment should be allowed every few weeks, unless the applications are themselves separated by a long interval.

8. The course of treatment should usually be protracted, since immediate and permanent results for chronic diseases are only accomplished in exceptional cases.

Concerning the prognosis it may be remarked—

1. In many, perhaps the majority of cases that are amenable to electrization, some slight temporary or permanent improvement will usually appear early in the treatment, or at least within a reasonable time after the treatment is begun, provided the *current is localized in the proper place.* Even if the special disease or symptom of disease is not relieved, there will be some incidental evidence that the treatment is taking hold. This rule is not without very striking exceptions. Some cases show no benefit whatever until after several weeks of treatment, and then they improve with great rapidity. The rule is, if improvement does not appear within a reasonable time,—say six or eight sittings,—to change the seat and the method of application.

2. Relapses or exacerbations and increase of evil symptoms do not necessarily contraindicate treatment. They are indications, however, for greater caution, milder, shorter, and less frequent applications; perhaps for a change of currents from galvanic to faradic, or the reverse; or for a different method of application.

3. The prognosis much depends on the age of the patient. Other conditions being the same, whatever the disease may be, it is less favorable with the extremely old or extremely young.

Galvanization of the central nervous system of very young children should be undertaken with caution. It should be considered that young children may suffer unpleasant symptoms from prolonged electrization which they are unable to express.

Prolonged galvanization of the upper or lower extremities of paralyzed infants, though very painful, and provocative of tears, does not seem to have even any temporarily injurious effect.

4. Electrization is contraindicated in those cases where positive injury persistently results from the cautious and wary use of short and mild applications.

The cases in which it is most likely to injure are active and severe congestions, inflammation or actual softening of the brain and spinal cord, and the most acute stages of peripheral inflammation, as well as in some conditions of extreme hyperæsthesia. Each case must be studied by itself experimentally, since with our present ignorance of pathology and the laws of disease we are oftentimes unable to judge, on simple *à priori* grounds, whether electrization is or is not contraindicated.

As a general rule, special caution should be exercised with those who do not well bear ordinary stimulants and tonics.

CHAPTER VI.

DETAILS OF APPLICATIONS OF LOCALIZED ELECTRIZATION.

It is necessary to bear in mind at the outset, that to produce powerful electrolytic effects on the brain, spinal cord, and sympathetic, the galvanic current is preferable to the faradic.

Galvanization of the Head.—The head may be electrized in a variety of ways, according to the supposed seat of the disease. One pole may be placed on the forehead and the other on the occiput; or both poles may be placed over the ears, or on the mastoid processes. Another method which we frequently adopt is to place the positive pole on the summit, over the supposed organ of firmness, and the other at the occiput.

To affect the base of the brain, the electrodes may be placed on the mastoid processes. To confine the action to one side of the brain, one electrode may be placed on the forehead, over the eye, and the other on the mastoid process of the same side. The patient may hold one of the poles in the hand.

Still another method is to place an electrode on each temple.

Less dizziness is caused if the current is opened and closed with the positive than with the negative pole. It is well, therefore, to first apply the negative pole.

Less dizziness is caused when the current flows through one side of the head, or from the forehead to the occiput, than when it is sent from one side to the other, through the mastoid processes.

With regard to the direction of the current, it is usually better to place the negative pole nearest the neck, and the positive pole nearest the forehead. But this rule is liable to many exceptions, and each case must be studied by itself.*

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* See remarks on direction of the current, p. 165.

Electrization of the head produces flashes of light through irritation of retina, and dizziness, which with many is disagreeable. If the application is too long continued, headache and insomnia, and general *malaise*, may result. Patients whom a short application through the head benefits are sometimes injured when the séance is protracted. Congestion, convulsion, and hemorrhage have arisen from a disregard of this rule. Galvanization of the head should be made with broad electrodes, with a stable current, which may be either uniform or increasing, and should not exceed one-half a minute or three-quarters of a minute, and with but from five to ten elements.

Galvanization of the Sympathetic.—The portion of the sympathetic to which galvanization is chiefly directed for therapeutical purposes is the cervical, although the cephalic, thoracic, and abdominal ganglia are unquestionably affected by it, though not with so specific, demonstrable, and immediate results.

There are a number of methods by which the superior, middle, and inferior cervical ganglia may be demonstrably affected by the galvanic current.

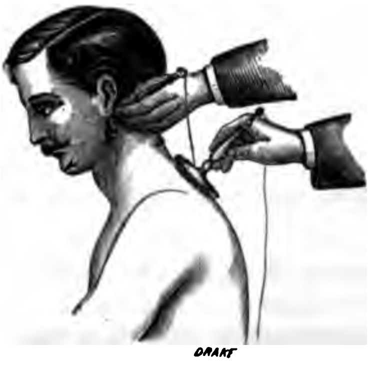

FIG. 40.

Galvanization of the cervical Sympathetic.

1. One electrode with an oblong extremity is placed in the auriculo-maxillary fossa, while the other with a larger surface is applied over, or by the side of the sixth and seventh cervical vertebræ.

The second electrode may also be applied at any point along the spine, from the occiput to the coccyx. It is by this method that diplegic contractions are usually produced with most success.

2. The first electrode being placed as before, in the auriculo-maxillary fossa, the other, with a surface of moderate diameter, is applied just above the manubrium sterni, by the side of the sterno-cleido-mastoid muscle.

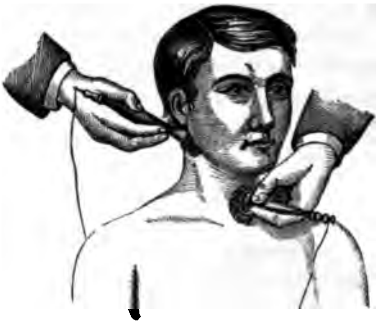

FIG. 41.

Galvanization of the cervical Sympathetic, including the Pneumogastric.

The second electrode may also be applied higher up in the neck, opposite the middle cervical ganglion.

These are the two methods which have been most frequently employed.

3. The first electrode being placed as before, the other may be applied on the shoulder, elbow, or in the hand of the opposite side.

4. Both sides may be galvanized simultaneously, by placing an electrode over the mastoid processes.

5. One electrode is placed just above the manubrium sterni, and the other at any point down the spine.

6. One electrode is placed over the sixth and seventh cervical vertebræ, and the other over the brachial plexus, at the pit of the stomach, just above the manubrium sterni, in either hand, or at the feet.

In all these methods either direction of the current may be used.

Concerning galvanization of the sympathetic, theory and experience seem to show pretty clearly—

First. It is difficult or impossible to pass the galvanic* current through the head, neck, and spine, without affecting more or less some of the ganglia of the sympathetic.

Secondly. Exclusive localization of the current in any of the ganglia of the sympathetic is impossible, since it is physically impossible to place the electrodes in such a position that other tissues will not be directly affected. Thus in the first method the current affects the spinal cord, in the second method the pneumogastric. The other methods affect the sympathetic still less exclusively.

Applications to the sympathetic should be made from one to five minutes, and with from ten to thirty cells. Several methods may be tried at a single sitting in cases where the applications are well borne. In order to produce diplegic contractions strong currents are sometimes necessary.

Galvanization of the Spine.—The spine may be electrized by placing one electrode at the occiput, and the other at the coccyx. Both the ascending and descending currents may be employed. The rule that has been given is, to apply the positive pole over the tender vertebræ or spot where the disease is supposed to be located, and the negative at some point above or below.† In localized electrization of the spine, of the brain, and the sympathetic, the galvanic current is found more efficacious than the faradic, but the latter is frequently of great service, and can be used for a longer time.

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* The same is probably true to a less degree of the faradic current. See chapter on Sympathetic.

† MM. Legros and Onimus (*Journal de l'Anatomie et de la Physiologie*

The current may also be localized in any part of the spine that may be required, by giving the electrodes the proper position. The spinal-cord current and spinal-cord-root current, spinal-cord-plexus current, spinal-cord-nerve current, spinal-cord-muscle current, of Benedikt, are all indicated in different conditions (see p. 181). The currents may be stable or labile—usually the former, since in pathological cases injury sometimes results from the use of strong labile galvanic currents on the spine. The applications may be made with twenty cells and upwards, and should not usually exceed five minutes. The applications should be sensitively felt, but should not be excessively painful.

Electrization of Plexuses, Nerves, and Muscles.—Plexuses, nerves, and muscles are treated by both currents (see chapter on differential indications for the use of the galvanic and faradic currents).

When the faradic current is used, applications to the plexuses, nerves, and muscles are entirely peripheral. One electrode may be applied to a plexus and the other to one of its branches, or to a muscle or group of muscles. Both electrodes may be applied to the nerve, or one to the nerve and the other to a muscle; or both may be applied to a muscle or group of muscles. All these applications may be made either with or without regard to the direction of the current, and different methods may be tried at the same séance.

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de l'Homme et des Animaux, No. Janvier et Février, 1870, p. 18) assign the general law, that "*the ascending current excites the spinal cord and increases the reflex actions, while the descending current prevents reflex actions.*" This proposition they support by a number of physiological and therapeutical experiments. The therapeutic results which they obtained by the descending current, though suggestive and striking, are yet no more so than those which have been obtained by the ascending current. On the general subject of the direction of the current, we refer to our remarks on page 165.

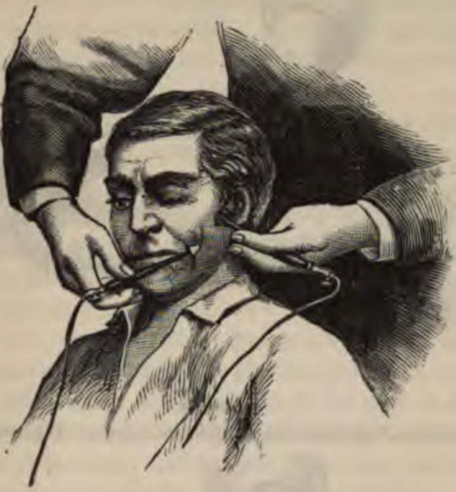

FIG. 42.

Faradization of the Facial Nerve and Muscles. Eyelid firmly closed and mouth drawn to one side.

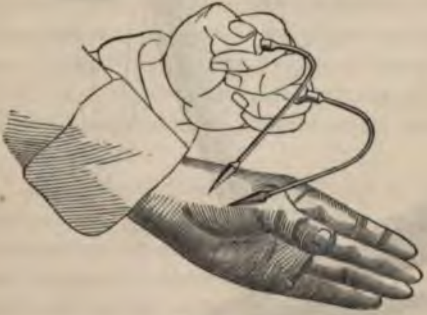

FIG. 43.

Muscular Faradization with metallic electrodes (Duchenne).

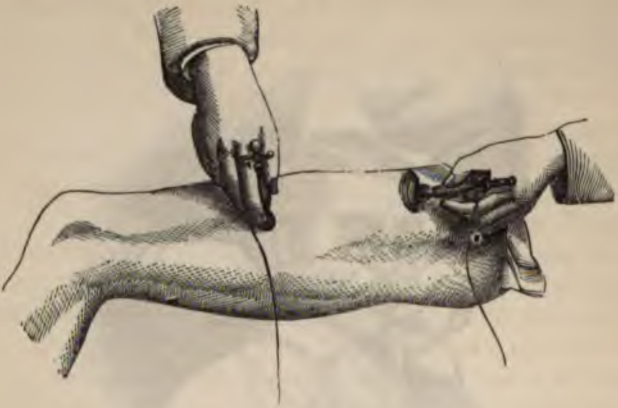

FIG. 44.
Faradization of the Muscles of the Thigh, contraction of the quadriceps.

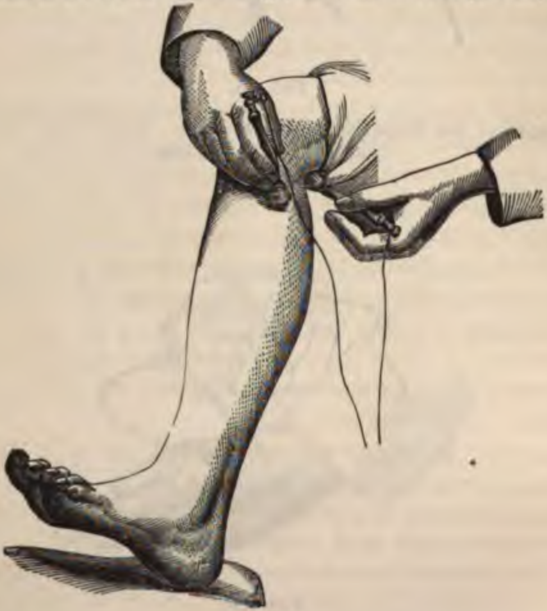

FIG. 45.
Faradization of Popliteal Nerve and Peroneal Muscles. Foot brought upward and outward.

In all the positions described in the above cuts, contractions should be produced with mild faradic currents, when the electrodes are in the position represented. If very strong currents are necessary or no contractions are possible, the muscles are in a condition of disease.

Peripheral applications are indicated where the disease is purely of a peripheral character; the partly central applications are indicated where the disease is of a central origin.

In galvanization the applications may be given either peripherally, or, like faradization, centrally; or in such a way as to include *some portion of the central nervous system.* In the latter method, one pole is placed on some portion of the spine, and the other on some nerve-plexus, nerve, or muscle.

In the use of the spinal-cord, plexus, and nerve currents to the *lower extremities*, it is an advantage to include as much as possible of the cord in the current. It is found that stronger effects are produced in these applications when one pole is placed on the cervical than on the dorsal or lumbar vertebræ.

Labile interrupted applications are indicated where it is desired to produce mechanical effects or muscular contractions, as in anæsthesia and paralysis.

Stable continuous applications are indicated where it is desired to produce chemical or catalytic effects, as in neuralgia.

The method of electrizing the eye, ear, nose, larynx, œsophagus, heart, lungs, stomach, liver, kidneys, spleen, intestines, rectum, bladder, male and female organs of generation, will be described in the chapters devoted to diseases of these organs.

The method of electrizing individual nerves and muscles will be described and illustrated in the chapter on electro-therapeutical anatomy.

Benedikt[*] makes the following subdivisions of the methods of *galvanization :—*

Spinal-cord current: both poles are placed on the spine, either near together, or at some distance from each other.

Spinal-cord-root current: one pole is placed on the spine, and the other is passed up and down by the sides of the vertebræ.

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[*] Op. cit., p. 56.

Spinal-cord-plexus current: one pole is placed on the spine, and the other on a plexus of nerves.

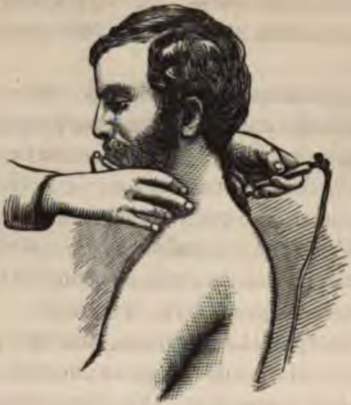

FIG. 46.
Spinal-cord-brachial plexus current.

Spinal-cord-nerve current: one pole is placed on the spine and the other on a nerve.

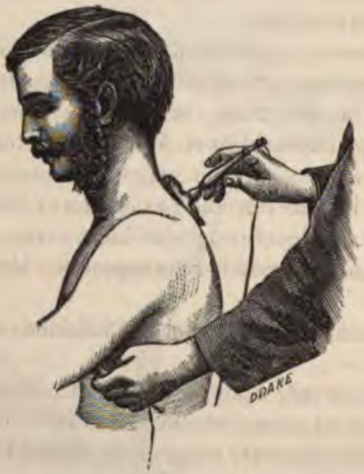

FIG. 47.
Spinal-cord-median nerve current.

Spinal-cord-muscle current: one pole is placed on the spine and the other on a muscle.

Plexus-nerve current: one pole is placed on a plexus of nerves and the other on a nerve.

Nerve-muscle current: one pole is placed on a nerve and the other on a muscle.

In localized electrization these currents may be either *stable* or *labile*, *continuous* or *interrupted*, *uniform* or *increasing*.

CHAPTER VII

EFFECTS OF LOCALIZED ELECTRIZATION.

LOCALIZED electrization has to a limited extent the same direct effect on the part to which the application is made that general electrization has on the whole body. It acts as a locally stimulating tonic.

The special effects of localized, unlike those of general electrization, cannot be broadly stated or classified, for the obvious reason that they must so largely depend on the locality to which the application is made.

Applications to the central nervous system are sometimes followed by mild and limited degrees of the primary, secondary, and permanent effects that result from general electrization; but the cases where the full order of these effects is so marked and decided as to be observed are comparatively unfrequent.

Applications to the brain and sympathetic system may be primarily followed by relief of pain, slight exhilaration, a feeling of warmth or somnolence; secondarily by fatigue, headache, or soreness of the muscles, or exacerbation of the morbid symptoms; and permanently by improvement in sleep, strength, and capacity for labor.

But this *order* of effects from localized electrization is exceptional, even from applications made to the head. More frequently the permanent effects are experienced without the primary, or perhaps both the permanent and secondary, and sometimes only the latter.

Yet none of these constitutional effects, in whatever order they may occur, are experienced to the extent that is derived from general electrization.

The agreeable symptoms which are most frequently observed after localized applications to the nerve-centres are ***disposition to sleep, relief of headache or other pain,*** and occasionally ***slight exhilaration.*** Among the disagreeable symptoms are ***dizziness, heaviness, oppression, headache, soreness in the back of neck, exhaustion, and indefinable nervousness.***

These disagreeable symptoms are most likely to result from applications that have been either too severe or too protracted for the condition of the patient; and yet they should by no means excite alarm, since they often accompany the most successful results. These unpleasant symptoms are more likely to follow the use of the galvanic current than the faradic, especially when the applications are protracted. The opinion that has been expressed by certain writers, that the head is more likely to be unpleasantly affected by the faradic than the galvanic current, is not sustained by experience. The phenomena of dizziness, heaviness, etc., frequently experienced after even a very short application to the head, are but rarely observed when the faradic current (A B, for instance, of Kidder's apparatus) is employed, with a large soft sponge, or the hand of the operator.

Applications of localized electrization to individual muscles or groups of muscles rarely give rise to any constitutional symptoms whatever, unless the electrodes are placed on or near the head.

A primary effect of electrization of a muscle or group of muscles is increase of temperature. (See p. 77, Electro-physiology.)

Sometimes the beneficial results of electrization of paralyzed muscles follow immediately after the application. The patient is conscious of an ability to use these muscles with greater ease and freedom. This improvement may be merely temporary, or, as is more frequently the case, partial relapses occur, leaving a certain amount of permanent benefit.

Immediate relief of neuralgic pain (hyperæsthesia), and of the reverse condition, anæsthesia, may follow localized as well as general electrization. The temporary relief of the neuralgia may be complete, while that of anæsthesia is usually only partial and limited. In both conditions the evil symptoms may recur, or a certain amount of permanent benefit may remain.

The effects of applications of localized electrization to special organs, as the eye, ear, larynx, stomach, liver, intestines, uterus, ovaries, bladder, etc., will be described in the chapters devoted to the treatment of the diseases of these organs.

Finally, it should be considered that ***exclusive and absolute localization of the effects of electrization is impossible.*** The effects of both currents, but especially of the galvanic, extend, either directly or by reflex action, to parts beyond the circuit. This is demonstrated, not only by physiological experiments, but by the observed facts of clinical experience. Thus it is observed, in some irritable conditions, that galvanization of the spine, and even of the extremities, causes a metallic taste; that galvanization even of the hands or feet sometimes hastens or increases the menstrual discharge, relieves headache, and produces sleep. The same effects to a less degree are sometimes observed from faradization.

CHAPTER VIII.

GENERAL ELECTRIZATION—MODUS OPERANDI.

The object proposed in general electrization is to bring every portion of the body under the influence of the electric current, so far as is possible, by external applications. This is best accomplished by placing one pole (usually the negative) at the feet or the coccyx, while the other is applied all over the surface of the body.

For this purpose either the faradic or galvanic current may be used, the faradic, however, is the current which is almost exclusively employed in general electrization, and, for that reason, the directions and explanations given in this section, with the exceptions that will be noted, apply mainly and specially to general faradization.

In the majority of cases it is more convenient and satisfactory to have a sheet of copper at the feet. This position is indeed the rule in general electrization. The broad, callous soles of the feet are but slightly sensitive, and will bear a stronger current than any other portion of the surface of the body. But the passage of electricity through the ankles causes vigorous contractions of the flexors and extensors, which, when the current is very strong, may be somewhat painful. Accordingly, when the patient is peculiarly nervous and sensitive, or when a current of unusual strength is to be employed, and in all cases where a stronger application is desired than can be borne through the ankles, or when it is desired to save time or inconvenience, it is advisable to have the patient sit on the plate, or a sponge electrode with a broad surface may be applied to the coccyx. The negative pole is placed at the feet or coccyx instead of the positive, because the descending current through the body is found by experience to be more agreeable and efficacious than the ascending. In this position of the poles the current, though descending for the trunk and lower limbs, is ascending for the upper extremities.

The lessons of experience concerning the position of the poles in general electrization are confirmed and explained in an interesting manner by the known phenomena of electrotonos, and by the results of experiments on the direction of the current.

1. It was stated in the section on Electro-Physiology (page 53) that the anelectrotonic portion of the nerve or muscle—that is, the portion near the *positive* pole—was in a condition of *lowered* irritability, while the catelectrotonic portion—that is, the part near the negative pole—was in a condition of increased irritability. Inasmuch as a large proportion of the diseases for which general electrization is indicated are associated with a condition of heightened irritability, and therefore demand a calming influence, the applications should be made with the positive pole. When, on the other hand, in the operations of general electrization, it is desired to produce contractions in paralyzed muscles, the current should be reversed by means of the current reversor, or by shifting the connection or the electrodes, so that we may obtain the increased irritability of the negative pole directly on the muscles. Thus it often happens in the treatment of the various forms of paralysis associated with general debility, that the positive pole may be appied over the head and trunk, and the negative over the paralyzed limb.

2. The descending current diminishes the excitability of the nerves, while the ascending increases it. When the negative pole is at the feet, and the positive is applied over the body, the current is *descending* for all portions of the body except the upper extremities. In the brain it is ascending with reference to the sympathetic centres, as Legros and Onimus suggest,* but this partial disadvantage, if it really exists, is counterbalanced by the fact, demonstrated by the same observers, that the *ascending* current *contracts* the blood-vessels, and thus diminishes the volume of blood in the brain.

By thus indicating the apparent accordance between the results of physiological experiments and clinical experience we do not wish to give the impression that the method of application here advised was suggested by, or is in any sense an outgrowth of electro-physiology. It was first established by very extended clinical experience, in a large variety of cases of disease, that in order to gain the full therapeutical results of general faradization with the least unpleasant effects, it was better that the descending current should be employed. Still further, the above-mentioned phenomena of electrotonos were only demonstrated for the galvanic current, whereas in general electrization the faradic current is used more than the galvanic.

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* Op. cit., p. 35.

Since electro-physiology and physiological chemistry are now, and for an indefinite period must continue to be, incomplete and progressive sciences—since, as it must be fairly admitted, physiology, like Saturn, is continually swallowing its own children, we are compelled for the present, in therapeutics at least, to subscribe to the dictum of one of the most distinguished of living physiologists, that *all experiments must yield to experience.**

Reasoning from the recognized principles of electro-physiology, as well as from experience, there would appear to be a positive advantage, in treating conditions of debility and irritability, to have the *electrodes separated by as wide an interval as possible, especially in applications to head and trunk.* The greater the distance between the poles, the longer must be the anelectrotonic (or diminished irritability) region.

Still further, according to Legros and Onimus,† the *direction* of the current, independent of the polar action, is more marked when a considerable distance intervenes between the poles.

Experience certainly declares in favor of a long intra-polar region in treating conditions of abnormal irritability. It is partly for this reason that localized electrization, even when applied successively over the surface of the body, can never be made a full and satisfactory substitute for general electrization.

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* See also an eloquent enforcement of this same view, with special reference to electro-therapeutics, in Prof. Niemeyer's Practice of Medicine, Hackley's and Humphrey's Translation, vol. ii. p. 290. Also, in preface to Benedikt's Electrotherapie.

† Op. cit., p. 82.

In general electrization, as in localized, the currents may be either *stable* (stationary), or *labile* (moving), *continuous* or *interrupted*, *uniform* or *increasing*.

Increasing currents are adapted for certain important centres, as the head, spine, cervical sympathetic, and cilio-spinal and epigastric regions. The advantage of this method of application is that it allows the use of a stronger current than will otherwise be borne; the strength of the current may be so very gradually increased that the increase within certain limits may be almost imperceptible to the patient. This arises partly from the fact that the current has a slight benumbing effect, and partly from the fact that by a gradual increase of the strength of the current the patient is spared the shock that is experienced when a strong current is suddenly directed through sensitive portions of the body. This advantage is especially noticed in applications to the head.

Labile—interrupted currents, are adapted for the muscles, especially of the extremities.

General electrization is very far from being so easy a process as it might appear from this brief description. Its successful employment requires, on the part of the operator, some mechanical dexterity, entire familiarity with the instruments required, a complete knowledge of electro-therapeutical anatomy ; a personal acquaintance with the sensations and behavior of all portions of the body under the different electric currents : close and patient study of the diseases and morbid conditions in which it is indicated, and of their response to electrization. There are those who by long practice are enabled, when necessary, to readily manipulate any portion of the body with either hand, while there is passing through them a current so powerful as to keep many of the principal muscles of the arms in a state of contraction. This qualification, however, though convenient, is not indispensable.

On the side of the patient, success in the use of general electrization requires simply self-control that does not flinch under a mild sensation of discomfort, and something of the same patience and perseverance that are conceded to be necessary for success in the use of any other form of tonic treatment Rarely or never is a patient found who cannot bear the application when properly administered.

Nothing is more difficult than to fully and accurately describe in words an operation that in its very nature demands actual sight and experience. The true method of learning the art of general electrization is by repeated observations of its application to the *living* subject, by personal experience of its sensations and results at the hands of practised adepts, and by long and various experimenting on diverse temperaments, and in opposite states of disease. We shall endeavor, however, to present the best possible substitute for a course of private lessons or extended clinical observation in this department, by answering in detail the practical questions that naturally present themselves to one who approaches the subject *ab initio*, and who has no opportunity for personal interviews with those to whom the various steps of the operation have become already familiar.

1. *Preparation of the Patient.*—General electrization requires free access to every part of the surface of the body. If proper pains be taken this can be done without causing any unpleasant exposure. Male patients should at first remove the stockings, unless it is preferred to sit on the copper plate, or to have a large sponge electrode at the coccyx, and all the clothing of the trunk, including the under-wrapper. If the room be cool, or if the patient be particularly sensitive, it is well to protect the shoulders with a shawl or wrapper. After the application has been made all over the head, trunk, and upper extremities, the patient may put on his underclothing, throw a shawl or wrapper over his shoulders, and should put himself in readiness for an application to the lower limbs by removing his pants and drawers.

With female patients such exposure is, of course, not required. It is necessary for them to remove only the stockings, the dress, and the corsets and the drawers. All the underclothing of the trunk may be retained, but it should be loosened in such a way that, without unpleasant exposure, free access may be had from beneath to all parts of the surface of the body. The shoulders should be covered by a shawl or wrapper, or loose morning dress.

When female patients prepare themselves in this way, they can be treated by general electrization as thoroughly and as successfully as males, if only proper tact, delicacy, and patience are exercised by the operator.

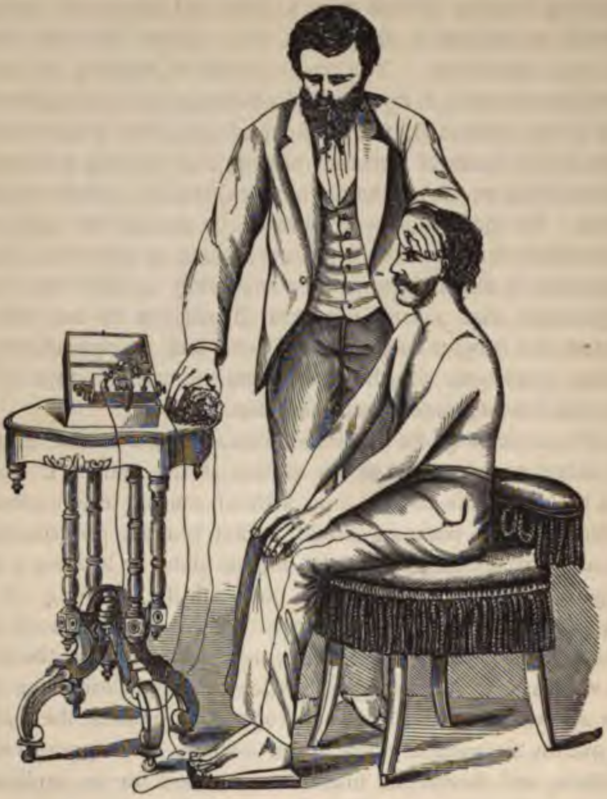

FIG. 48.

GENERAL FARADIZATION—application to the head by the hand of the operator. (In this, as in all of the cuts of general electrization, for convenience of illustration the patient is represented without any covering. In the majority of cases they are protected by a shawl or wrapper, and frequently the underclothing is not removed.)

2. *Position of the Patient.*—The patient should be seated on an ordinary stool, with his face toward the instrument, and his feet on the sheet of copper to which the negative pole is attached. Any chair that has a back or arms will interfere with the manipu-

lations of the operator, and should only be allowed to those who are so feeble that they cannot sit up unsupported.

Those patients who, through paralysis or debility, are unable to sit up at all, can receive the treatment while lying in bed or on a lounge. In such cases the sheet of copper may be placed upright against a pillow and the feet of the patient pressed against it, or an electrode may be placed at the coccyx. Assistance will then be required to turn the patient when the application is made to the back and spine, but in such cases partial applications are frequently all that is required.

Infants and very feeble or very timid children should be held in the lap of the mother or nurse, while an assistant holds the sponge to the coccyx.

While the application is being made to the lower limbs it is well for the patient to stand, in order that the operator may have access to the gluteal regions and the posterior and anterior surface of the thigh.

Position of the Operator.—While making applications to the trunk, the operator may either stand or sit by the side of the patient, conveniently near to the table, on which are placed the apparatus, electrodes, sponges, bowl of water, and other appliances that may be called for during the application. It is important for him to be so near to the instrument and the bowl of water that, without changing his position, he can instantaneously modify the current to any strength that he may desire. As it is necessary to moisten the hand very frequently during the applications that are made through the operator's own person, pains should be taken to have the bowl of water also within convenient reaching distance.

While operating on patients taller than himself the operator will find it easier to stand, especially while treating the head and upper portion of the trunk. While treating short patients the operator will find it less fatiguing to sit in a chair. Most operators will find it very convenient to change their position from a sitting to a standing posture, or from one side of the patient to the other, while making the applications to the various parts of the trunk.

Some accustom themselves to making the applications entirely with one hand; others use both hands with equal ease.

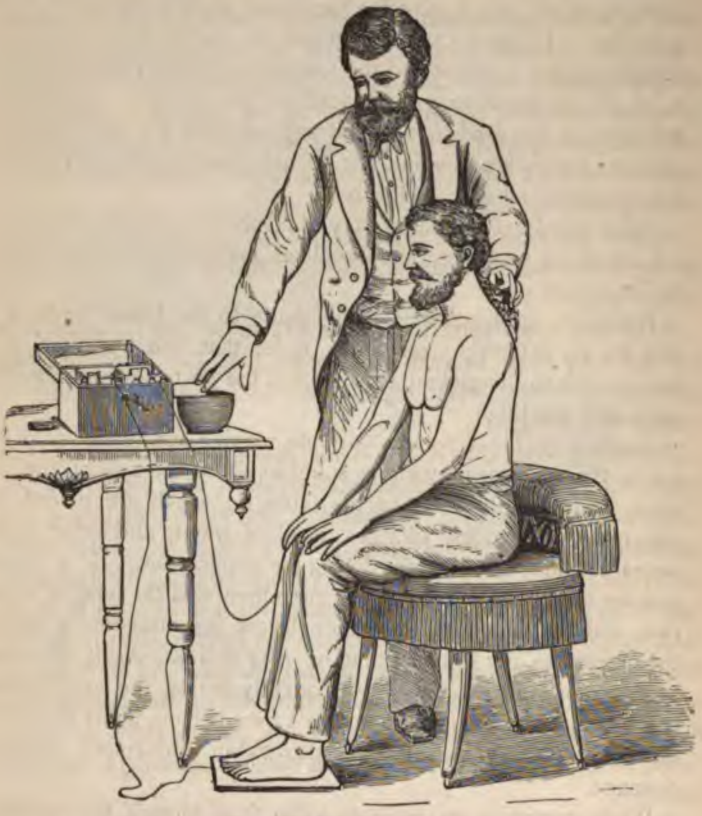

FIG. 49.

GENERAL FARADIZATION—application to the spine. The hand of the operator is on the metallic tube, in a position to increase or diminish the current as may be needed.

In making applications to the lower limbs, while the patient is standing, it is well for the operator to sit on a very low stool or ottoman.

Kind of Current to be Employed in General Electrization.—In general electrization both currents can be employed either separately or simultaneously, in the form of *galvano-faradization.*

As a matter of experience, very many of our best results in general electrization have been obtained with the faradic current alone. And yet we continually used the galvanic current in the form of general electrization, and, so far as we know, were the first to employ this method of treatment. In some of our cases we employ the faradic current one week and the galvanic the next. Sometimes we alternate the two currents, or use them in succession at the same sitting. For reasons which will be obvious on a consideration of the differential indications for the use of general and localized electrization and the difference in the effect of the two currents, the purposes of general electrization are usually better met by the faradic than the galvanic currents.

Minor Apparatus—Electrodes, sponges, copper plate, and bowl of water.

The minor appendages that are necessary for the application of general electrization are very few and can be easily described. The best electrode for the pole that is applied over the patient is a brass ball of about one inch in diameter. (This is represented in the cut of Kidder's apparatus.)

Nothing seems to be gained by making these brass balls either much larger or much smaller than the size here indicated.

Around this brass ball should be loosely folded a soft, wet sponge, of about six inches in diameter. This is found, by experience, to be by far the most convenient form of artificial electrode that can be devised. Next to the moistened hand of the operator it is the most agreeable to the patient of any shape or quality of electrode. The sponge can be pressed or folded over the brass ball so as to make a comparatively small electrode, or its entire surface may be applied.

When the operator allows the current to pass through his own person, and uses his hand as an electrode, holding the sponge and ball in his other hand, he can modify the application to any degree of strength or mildness that he may desire, by simply increasing or diminishing the pressure of his hand or fingers on the sponge. When it is necessary that the application should be particularly gentle and cautious, it is well to rest the ball and sponge on the table, and to begin the treatment by first pressing one hand *firmly* over the part desired to be affected, and with the other lightly and delicately touching the sponge, at first with one finger, then with two, three, and four successively, and finally with the whole hand, thus giving a very gradually *increasing current.* In the majority of cases in which general electrization is employed, the only artificial electrode needed is that which has been described.

Special electrodes, for the eye, ear, larynx, uterus, &c., are usually required only in localized electrization.

A *piece of copper plate* is recommended for the negative electrode, because it is found by experience to be, on the whole, more convenient than any other arrangement that has yet been suggested. The bowls of warm water, large sponges, &c., that have been suggested, are not only much less cleanly and convenient than the copper plate, but are also much poorer conductors. It is obvious to any one that the poorer the conductor at the feet, the stronger the current that must be used to overcome its resistance. Metallic slippers are more troublesome than the broad plate, though their appearance, perhaps, is more ornamental. It needs more care to put on the slippers, and if the patient loses his self-control during any stage of the application, and throws up his feet, it is something of a task to find the slippers again and accurately adjust them.

In the use of the copper plate these *three* details must not be forgotten: *First*, to keep it well warmed by a piece of heated soap-stone; *secondly*, to keep it slightly moistened with warm water in order to improve the connection; and, *thirdly*, to have *both* of the feet applied to its surface.

If only one foot is applied to the copper plate the pain in the ankle, during certain stages of the application, will be unendurable. It is necessary ever to bear in mind the rule, that the pain of electrical applications, other conditions being equal, is in *inverse* proportion to the surface of the electrode. The *larger* the surface of the electrode—whether positive or negative—the less the pain. In this fact consists the advantage of using large sponges.

The bowl of tepid water should be placed by the machine and within convenient reaching distance. If a little common salt is placed in the water its conducting power is much increased.

In general electrization the pain at the negative pole is chiefly felt at the ankles, and somewhat at the toes, but not on the bottom of the feet. The feeling of constriction in the ankles is caused by the rapid and violent contractions of the muscles. If only one foot is applied to the plate the entire force of the current must, of course, be borne by that foot, and furthermore, the other limb will receive no direct benefit from the treatment.

Methods of Modifying the Strength and Quality of the Current during the Application.—The strength of the faradic current may be modified during the application of general electrization in *three* ways: First, by changing the negative pole from D to C or B (in Kidder's apparatus). A B gives the mildest current, such as is oftentimes used for the head. A C gives a stronger and more concentrated current. A D gives the full power of the machine, and is the strongest of all the currents, except as the metallic tube is nearly or quite removed, when D C becomes the stronger. (These details are explained more fully in the chapter devoted to the description of the apparatus.)

A *second* method of modifying the character of the current is by removing the conducting wire with which the electrode is connected from the holes A, B, C, or D, and then giving "shocks" by rapidly interrupting the current, the positive pole being all the while pressed firmly on the spot desired to be affected.

A third method of modifying the current, and one that must be employed momentarily during every stage of the process of general electrization, is by changing the position of the metallic tube that covers the helix. When this is pushed in the current is very feeble; when it is entirely withdrawn the current is at its strongest.

When the operator applies the brass ball and sponge to the body he can keep his free hand all the time on the metallic tube, and push it in or withdraw it at pleasure. *Facility, skill, and readiness in use of these methods of modifying the strength and quality of the current is one very important secret of success in the use of general electrization. A skilful operator will cause less* *discomfort with a strong current than one who is awkward will cause with a very weak current.*

DETAILS OF THE APPLICATIONS TO THE DIFFERENT PARTS OF THE BODY.

Inasmuch as general electrization requires that the applications should be made over the entire surface of the body, and as the various parts and organs of the body differ very widely in their susceptibility to electrization, and in the effects which they receive from it, it becomes necessary to explain the *modus operandi* of the applications with considerable fulness of detail.

Applications to the Head.—Applications of electricity to the head are perhaps the best tests both of the efficacy of general electrization and of the skill of the operator. The head, especially the forehead, is, by far, more sensitive to the electric currents than any other portion of the surface of the body. The *two* reasons for this are sufficiently obvious. The surfaces of bones are always sensitive to the *faradic* current, as to any other mechanical influence; and the cranium is no exception to this law. Then, again, the fifth pair is an exceedingly sensitive nerve in all its ramifications, and especially over the forehead. The brain itself is also more or less sensitive to the current, especially to the galvanic. The brain itself is directly affected by applications of electricity over the cranium, but not painfully so, unless a very strong current is employed. (For proofs that the brain is directly affected by applications of electricity to the head, see Electro-Physiology, page 86 et seq.)

Application to the head is usually, and as a matter of convenience, the first step in the process of general electrization. There are many cases that do not bear even mild applications to the front and top of the head, and who seem to be injured rather than benefited by it. With others, on the contrary, the effects are highly agreeable.

In treating the forehead the operator should first press his moistened hand firmly over the head, and then making the connection with his other hand on the sponge and brass ball of the positive pole, should allow the current to pass steadily, without interruption, for one or two minutes. In Kidder's faradic apparatus, A B is the best current for the forehead. When the galvanic current is used the treatment should be still milder. The use of the hand as an electrode is particularly desirable in making applications to the forehead. The best form of artificial electrode for the head, whether the galvanic or faradic current is used, is a large, soft sponge.

The dry hair is a non-conductor, and therefore it is always necessary to *wet it freely before electrizing* any portion of the head that is covered by it. It is not usually desirable to compel lady patients to pull down their hair, or to thoroughly moisten it. It is generally sufficient to electrize only that portion of the cranium which is readily accessible. In electrizing the top and sides of the head the stable current should generally be used. A very important centre for affecting the brain is the crown of the head, between the ears, over the so-called organ of firmness,—the cranial centre. If the hair at this point be sufficiently moistened to admit the passage of a mild current with any convenient form of electrode, a peculiar and slightly painful sensation is experienced that seems to proceed from the brain itself, and is certainly very different from that which is felt by the branches of the fifth pair on the forehead.

It is at this point also that nervous and hysterical patients frequently suffer from burning pain—from a sensation as though a hot coal of fire were resting there.

In some exceptional cases of disease the head will bear currents of considerable strength. The back of the head over the cerebellum will usually bear quite strong applications. The current is felt through the ramifications of the occipital nerves, giving rise oftentimes to sensations not only painless, but absolutely agreeable.

Applications to the Eye.—The eye is much less sensitive to the current than either the face or the forehead. The temporary and permanent relief that is afforded to the eyes when in a condition ot asthenopia, or simple exhaustion from overwork, is oftentimes very striking. Of the eye as of the forehead it may be said that it is always best electrized by the hand and fingers of the operator. The moistened fingers should be drawn over the closed eye towards each other, with light and gentle pressure and slow movement. The labile current is preferable to the stable, or, at least, is equally as good, and usually considerable strength is borne without discomfort.

Applications to the Ear.—A strong current applied over the tragus, or just below the auricle, is about all that is necessary or advisable in general electrization.

Special diseases of the eye and ear must often be treated by localized electrization, with the apparatus and according to the methods described under the diseases of those organs.

Applications to the Face.— Except in cases of paralysis of motion or sensation, or of both, it is not well to make any applications to the face beyond a slight pressure over the fifth pair, on the tragus, as described above. A mild current applied at this point will produce thorough contractions of all the muscles on one side of the face.

Applications to the Neck and Throat.—The back part of the head and upper portion of the spine will usually bear powerful applications. It is an interesting and important fact *that very marked effects may be produced by general electrization, even when the applications are made only to the back and sides of the neck.*

The reason for this will be clear when we come to study the *electro-therapeutical anatomy* of the parts. From the upper portion of the spine and base of the brain proceed the most important and most sensitive nerves of the body—the pneumogastric, and the brachial plexus, and the phrenic nerves.

Furthermore, the sympathetic or ganglionic system runs close by the spine, near to the carotid artery, and may be reached and affected electrically by pressing firmly with the fingers, by the anterior border of the sterno-cleido-mastoid muscle, at those points where the pressure of the carotid is most readily felt.

It is also probable that the cephalic ganglia of the sympathetic are more or less influenced when the electric currents are passed through the head.

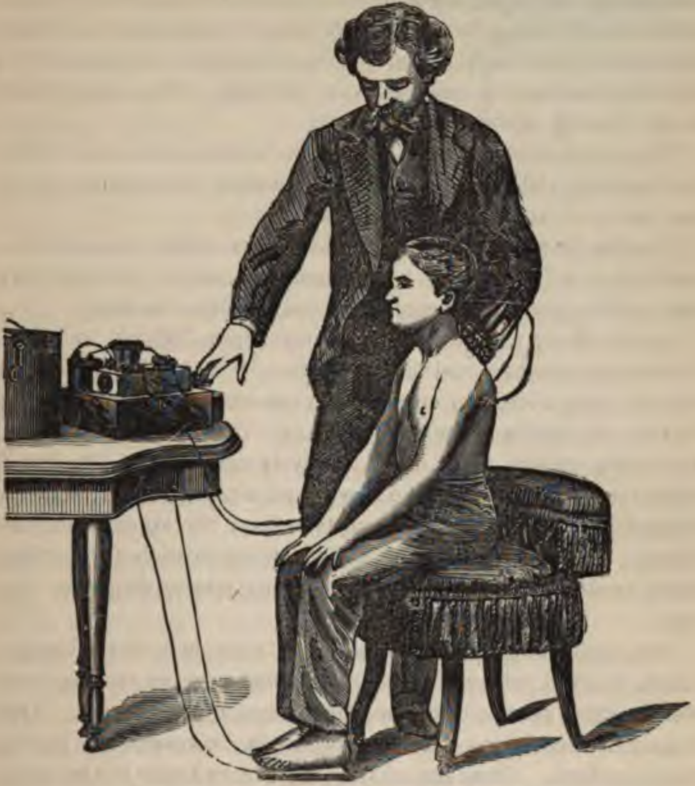

FIG. 50.—GENERAL GALVANO-FARADIZATION.

A double electrode is used, one part of which is connected with the galvanic and the other with the faradic apparatus. The copper plate is also connected with both currents.

If the sponge be pressed firmly on the cilio-spinal centre, over the sixth and the seventh cervical vertebræ,* and moved slightly on either side of the spine (see figure 49, page 194), while a powerful current is passing, the electric influence may be *perceptibly* communicated not only to the spine, but also to the larynx, through the laryngeal nerves, to the stomach through the pneumogastric, to the lungs through the phrenic, to both arms and hands through the brachial plexuses and their branches—*in short, to the most important nerves and organs of the body.* The sympathetic is also directly affected at this point.

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* See Electro-Physiology, p. 63.

There is no other single place on the surface of the body where the electrical influence can be communicated to so many important nerves as at the cilio-spinal centre.

In order, however, to affect all these nerves and organs above mentioned by faradization it is necessary to use a powerful current, and to press the sponge very firmly against the skin.

In very fleshy patients it is sometimes quite difficult to affect the brachial plexuses and their branches in the arms and hands without using a stronger current than can well be borne through the feet and ankles at the negative pole. This application, so far from being painful, is to many positively agreeable. The *thrill* which it communicates to the nerves and vital organs is often so delightful that the patient requests to have the application prolonged. In patients who can bear it this application at the ciliospinal centre may be varied by suddenly interrupting the current.

This application is a very important factor in general electrization, and will achieve decided tonic effects on the system, even when no other portion of the body is touched by the current. The immediate sensations which it produces, however, are by no means uniform. Some patients, through the irritation of the laryngeal nerves, cough spasmodically, and even violently, under the excitation even of a comparatively mild current; with others, even the most powerful currents, and the firmest possible pressure of the sponge, fail to produce any such effect. In nervous and sensitive patients this application often causes a peculiar and decided sensation in the stomach, through the pneumogastric nerve; the strong and vigorous rarely experience any such sensation, even under currents of great power. The sensation of tingling and pricking in the fingers, caused by the excitation of the branches of the nerves of the arm, can almost invariably be produced, even in the very corpulent.

In patients suffering from organic disease of the spinal cord, or probably from simple spinal exhaustion, even mild applications over the upper portion of the spine may cause painful sensations through the entire length of the cord, and down the lower extremities to the feet. This fact is one of great diagnostic value, because it is well established that in a normal condition of the spinal cord no such sensations are transmitted, at least under the form of application above described.

Another important locality in the electro-therapeutical anatomy of the neck is in the posterior triangle, just by the posterior border of the sterno-cleido-mastoid muscle. If the fingers of the operator, with a current of considerable strength—the sponge, with a current comparatively mild—be pressed firmly on this space until the posterior border of the scalenus anticus is reached, the patient will at once experience a tingling or pricking sensation in the arm and hand on that side, caused by the excitation of the brachial plexus, and in some cases a thrill is communicated by means of the pneumogastric to the stomach, and by the phrenic nerve to the diaphragm.

In cases of paralysis or anæsthesia of the arm this application is of invaluable service, and in all cases of general debility it is decidedly indicated. Another important locality in the electro-therapeutical anatomy of the neck is just above the sternum. Applications should be made here in all cases of debility, but especially in patients afflicted with chronic bronchitis. At this point the inferior cervical ganglion can be irritated. Beside all these special applications, the electrode should be passed rapidly, thoroughly, around and over the entire surface of the neck, anteriorly and posteriorly, and should be pressed firmly and thoroughly by the anterior border of the sterno-cleido-mastoid muscle, until the beating of the carotid artery is felt, in order to affect the sympathetic.

Applications to the Upper Extremities.—In electrization over the extremities, the sponge, or the hand of the operator, should be passed thoroughly over the surface of the hands and arms, and with sufficient force to produce agreeable contractions of all the superficial muscles. In cases of paralysis of motion or of sensation of the whole upper extremity, or of any portion of it, it is well to have special reference in the applications to the course of the principal nerves. Except in infants and corpulent females, contractions of the superficial muscles of the arm are obtained with a mild current.

Applications to the Spine.—The spine may be treated both with labile and stable currents. When it is in a condition of irritation or inflammation, stable galvanic currents are to be preferred. Stronger currents of electricity may be borne over the middle of the spine than perhaps over any other portion of the body. The reasons for this are sufficiently apparent. The back is less sensitive to any irritant than most of the other portions of the surface of the body. There are no very sensitive peripheral nerves in the back, and the spinal cord is so thoroughly protected by its bony covering that the currents are never felt in it painfully, except when it is greatly exhausted or organically diseased. The nerves that issue from the spinal cord are more or less affected by powerful applications to the back, and through them the various parts and organs which they supply are considerably influenced.

The best method of electrizing the back is to pass the sponge down its entire length, from the first cervical vertebra to the *cauda equina*, carefully avoiding the prominences of the scapula and the ossa innominata. Below the inferior angle of the scapula the sponge may be moved from side to side over the region of the kidneys, liver, and spleen.

In cases of nervous dyspepsia, a peculiar and almost painful sensation is sometimes felt in the region of the stomach as the sponge is passed over the portion of the spine from which the solar plexus takes its origin. The liver and spleen are sometimes exceedingly sensitive, and in other cases seem to be in a condition of anæsthesia. The ultimate effects of electrization of the spine, on the lungs, bronchial tubes, and heart, are decided, but the temporary sensations experienced in these parts during the applications are very slight indeed.

In that very frequent and very harassing and indefinite accompaniment of nervous disorders, back-ache, which is so frequently associated with spinal irritation, the sponge may be pressed with moderate firmness over the painful spot, and allowed to rest for a few moments, until relief is experienced.

If a strong current be applied over the lower portion of the spine, between the upper borders of the ossa innominata, a slight sensation is sometimes, though by no means uniformly, communicated to the rectum and the male genital apparatus, the penis and the testicles, through their spinal nerve-supply.

If a strong current be applied over the lower part of the *cauda equina*, both sciatic nerves and their branches are very sensitively affected. In cases of paralysis of the lower limbs, suddenly interrupted currents in the form of shocks may be given at this point with advantage. In view of these considerations it is manifest that in the *employment of general electrization particular attention should be given to the spine, even at the expense of neglecting other portions of the body.*

Applications to the Lungs and Heart.—The lungs and heart are less affected by general electrization than any other of the prominent vital organs, and partly for this reason, the diseases to which they are subject—even the neuroses—are less amenable to electric treatment than are corresponding diseases in other organs.

That the lungs and heart are less influenced by electrization than other important organs is chiefly accounted for by the anatomical structure of the chest. The ribs, with the intercostal muscles and ligaments, form an unyielding wall. Furthermore, the pleura and pericardium are not closely adherent to the inner wall of the chest, but lie loosely over the lungs and heart. These organs, therefore, are best affected electrically by applications above the sternum, around the neck, and over the upper half of the spine whence the nerve-supply of the viscera proceeds, and by direct electrization of the vagus in the neck.

Applications over the chest are, however, of positive and permanent service, by developing the thoracic and intercostal muscles, and for this reason, if for no other, they should not be neglected. But it should not be forgotten that the surfaces of the ribs, like the surfaces of all other bones, are sensitive to electrization, and that therefore the chest will not bear as severe applications as the spine, neck, or abdominal regions. This sensitiveness is, of course, more in the thin and nervous than in the corpulent and phlegmatic. It is usually most marked on the *inferior ribs on the right and left side of the body*, over the liver and spleen. The peculiar sensitiveness of the ribs at these points is sometimes erroneously supposed to indicate disease of the organs beneath them.

Applications over the Stomach, Liver, Spleen, and Bowels.—The digestive apparatus can be materially, and, as has been stated, sometimes sensitively, affected by electrization applied to the lower half of the spine; but, in order to thoroughly influence these important organs, the sponge or the hand of the operator should be applied directly over the regions of the stomach, liver, spleen, and bowels.

We have stated above that the anatomical structure of the chest rendered it difficult to send the electric current through the anterior of its walls to the lungs and heart. In the abdominal regions the anatomical structure is directly reversed, and instead of an unyielding wall, partly composed of bones and ligaments, we have a flaccid skin lying loosely against the peritonæum that covers the moist viscera beneath. It will be recollected that the tissues of the body conduct electricity in direct proportion to the saline solutions which they contain. (See p. 84.) No other organs of the body contain so large a percentage of water as those which are situated in the cavity of the abdomen. It is obvious, therefore, that when the resistance of the epidermis is overcome by the moisture of the sponge or hand, and the peritonæum and viscera are brought into coaptation, the current must directly traverse all the parts desired to be affected.

In making applications of electricity to the anterior surface of the trunk below the diaphragm, particular attention should be given to the epigastric region.

The stomach participates more or less in nearly all the neuroses for which we employ general electrization, and the solar plexus from which it receives its nerve-supply is certainly the most important plexus in the body.

To reach the stomach and solar plexus place the sponge or palm of the hand below and under the sternum and as far back as possible. This pressure brings the peritonæum and stomach into coaptation and forces the current to pass through them. In the dyspeptic and feeble it is necessary, at first, to use very mild and short applications over the stomach; and in such cases it is almost indispensable, if a strong current is used, that the operator should allow the current through his own person. The spleen and liver may be treated in the same way as the stomach, or by gentle passes from side to side.

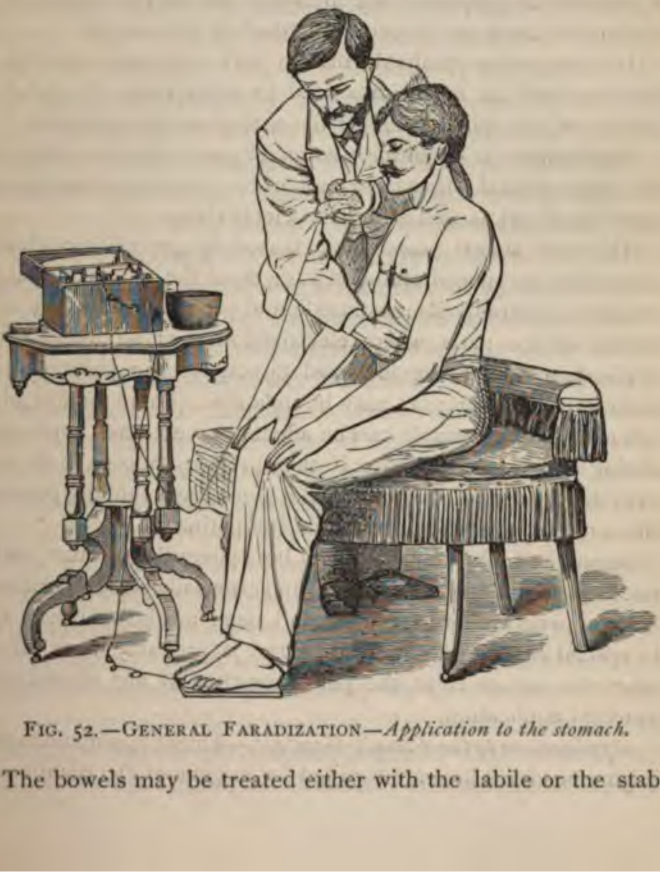


FIG. 52.—GENERAL FARADIZATION—*Application to the stomach.*

The bowels may be treated either with the labile or the stable current, and, in cases of obstinate constipation, by sudden interruptions or shocks.

Corpulent and pursy patients usually bear much stronger currents over the abdomen than the thin and emaciated. Adipose tissue is comparatively a poor conductor of electricity, and it is difficult to affect the bowels of the very corpulent through the abdominal walls, by electrization, unless we employ firm pressure and currents of considerable strength. But in the vast majority of cases currents of moderate strength, applied lightly over the surface of the abdomen, either with the sponge or with the hand, will readily produce contractions of the abdominal muscles, and, if pressure be employed, the intestines and all the organs of the abdominal cavity are directly traversed by the current.

It is somewhat probable that in very corpulent patients the intestines will be more influenced by applications to the lower portion of the spine than over the surface of the abdomen.

Applications to the Male Genital Organs.—Special diseases of the male genital organs, as impotence, spermatorrhœa, &c., demand localized as well as general electrization.

That the sexual power is increased by general electrization, even when no special attention is given to the genital apparatus, we have repeatedly demonstrated; and yet in all cases of positive disease of the parts, where electrization is at all indicated, the applications should be localized directly to the perinæum, the testicles, or the penis, as may be indicated. There are five places where the male genitals can be affected by external applications during general electrization if the operator chooses to do so,—over the hypogastric region, on the penis, between the penis and the scrotum, over the scrotum, on the perinæum.

Strong currents are usually well borne over the scrotum, and between the penis and the scrotum, and especially on the perinæum; but the penis is more sensitive, and need not be touched except in special cases. The prostate gland is probably more affected when the sponge is at the perinæum than by any other form of external application.

Applications to the Female Genitals.—Direct applications to the vagina or uterus are rarely called for in general electrization.

That the uterus is influenced by general electrization is proved continually by the fact that some of the diseases to which it is subject are relieved or cured by this method of treatment alone.

When a strong current is applied over the lower part of the abdomen, with considerable pressure, the uterus and vagina are traversed, to a greater or less extent, and are correspondingly affected. The current may also be sent through the ovaries by applying the electrode directly over them. In corpulent females we experience the same difficulty in affecting the womb and ovaries that we have in reaching the intestines. In these, as indeed in all cases, it should not be forgotten that very much may be accomplished for these organs by strong currents down the lower portion of the spine, whence proceeds their nerve-supply.

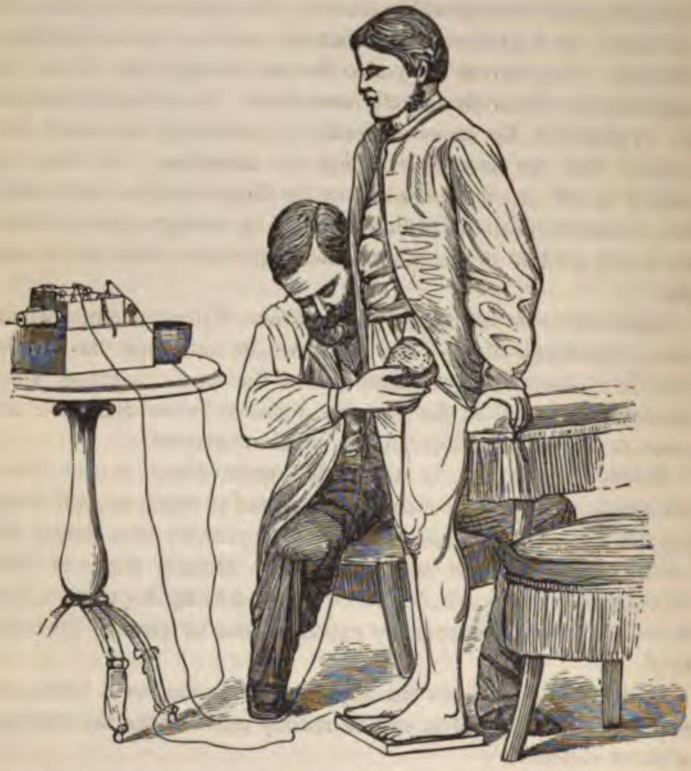
Applications to the Lower Extremities.—Unless there is weakness or paralysis of the lower limbs we do not apply the current directly to them in more than half of the cases, because, when the copper plate is at the feet, the muscles below the knee are more or less exercised during the whole treatment.

Before proceeding to make the applications to the lower extremities, the patient should be required to stand up, still keeping the feet on the copper plate. Male patients who, during the earlier stages of the operation, have entirely removed their clothing from the trunk, should be allowed to again put it on, both in order to avoid unnecessary exposure and to protect from the cold.

With female patients the applications to the lower limbs, except in cases of paralysis, can be readily made under the clothing, without exposure.

The operator, sitting by the side of the patient, on a low stool or ottoman, should then pass the sponge or the hand lightly down the entire surface of both limbs from the thighs to the feet, avoiding, so far as possible, the prominences of the bones at the hip, knee, and ankles.

The outer portion of the thigh, like the back, is very little sensitive to the electric current, because its surface is not supplied by very sensitive nerves. The inner side of the thigh, on the contrary, is supplied by branches from the sensitive anterior crural nerve, and in nervous persons especially is very susceptible to electrization. In passing the sponge or the hand down the lower limbs great pains should be taken to carefully graduate the current according to the sensitiveness of each locality. It is well for the operator to keep his hand all the time on the metallic tube, so as to be able to modify the current instantly and at pleasure. This precaution is more necessary in treating the lower



GENERAL FARADIZATION—*Application to the Lower Extremities.*

limbs than the upper, because the contrasts in the normal sensitiveness of the different parts of the lower limbs are much greater than in the arms, and because any severe shocks suddenly felt in the legs sometimes throw patients off of their feet.

In cases complicated with paralysis of motion or sensation of the lower limbs it is well, in these applications, to reverse the current, so that the positive may be at the feet, having special reference to those points where the principal nerves lie most superficial. These points are, for the *sciatic nerve*, between the head of the femur and the tuberosity of the ischium ; for the *anterior* crural nerve, just below Poupart's ligament and in the middle of the thigh, by the border of the sartorius ; for the *popliteal nerve* in the outer portion of the popliteal space, by the tendons of the biceps muscle ; for the *anterior tibial nerve*, the point by the border of the tibia, from five to seven inches below the knee-joint ; for the *posterior tibial nerve* just posterior to the internal malleus. In cases of paralysis, where it is necessary to make strong applications to these sensitive points, it is advisable to allow the patient to sit in a chair or recline on a bed or lounge.

In cases not complicated with paralysis, contractions of the superficial muscles of the lower limbs can be produced by comparatively feeble and painless currents.

CHAPTER IX.

SPECIAL RULES TO BE OBSERVED IN THE EMPLOYMENT OF GENERAL ELECTRIZATION.

In the employment of general electrization there are certain rules and cautions on the observance of which the results of the applications will very materially depend.

The *dose* of general electrization, like the dose of cold bathing or of physical exercise, is a compound quantity, made up of several factors. The dose of a shower-bath includes the temperature of the water, the violence of the shower, and the length of time that the patient is subjected to it. The dose of general electrization includes the *strength of the current, the thoroughness of the application, and the length of the séances.* In employing this treatment, therefore, it is necessary to regard all these *three* elements, studiously adapting the treatment to the constitution of the patient and the nature of the disease.

It is important to consider—

1. *The Strength of the Current.*— It is better that the first tentative applications should always be made with a gentle current, and, if the patient be particularly sensitive, it is an advantage with the hand of the operator instead of an artificial electrode. After the patient has become somewhat accustomed to the treatment, the general rule should be to make the applications *pleasantly painful.*

But to this rule there are marked exceptions. There are individuals who, from some native peculiarity of constitution, are so exceedingly sensitive to tonics, that they can only take quinine, iron, strychnine, &c., for a very short time and in doses far less than the average. Doses of these remedies which to others are decidedly beneficial cause in them the most intense and even alarming reaction. Such patients are also abnormally sensitive to general electrization, and accordingly must be treated with peculiar caution.

Patients who have long been accustomed to the treatment—who have become, in a certain sense, insensible to the strength of current ordinarily used—may frequently be benefited by very powerful currents, such as may be obtained by uniting two or three batteries to the helix.

Usually, but not invariably, we may be guided by the sensations of the patient; but exceptions to this rule are sometimes very striking, and should put us on our guard. Some who feel no pain during the applications may on the day following experience the most disagreeable reactive effects.

Thoroughness of the Applications.—General electrization does not require that all portions of the surface of the body should be touched by the electrode at every sitting. In nervous and susceptible patients we can approach the full measure of the treatment only by slow degrees. It is oftentimes sufficient to make the first application only around the neck, shoulders, and on the upper portion of the spine. Patients have such erroneous impressions in regard to the nature of the treatment, are so wrought upon by the memories of the frightful "*shocks*" which they have received in their school days, that they oftentimes enter the operating room with dread, as though they might never come out again alive. It is clear that such timid and misguided patients must at first be handled tenderly, until they gradually learn by actual experience that general electrization is, on the whole, a most agreeable process, and that, at most, it need never cause them anything more than a feeling of mild discomfort.

It is not always necessary, in every case, to make the applications to all portions of the surface of the body, even in a prolonged course of treatment.

The general tonic effects of this system of treatment can undoubtedly be achieved without touching either the upper or lower extremities. But, on the other hand, it is just as undoubtedly true that the muscular development that results from long-continued electrization of the arms and legs reacts favorably on the whole system and materially aids the treatment.

The general rule should be that, in all cases of *general debility associated with some local disorder, the applications should be made all over the body, but with special reference to the part affected.* In deviating from this law of thoroughness each case must be studied by itself. Thorough applications to the head, or at least to all portions of it, are not demanded in more than half the cases for which general electrization is indicated. In some cases very marked benefit is derived from applications over the head; in others the results are negative. It is usually sufficient to place the hand over the forehead, as directed, and on the top of the head, and over the cerebellum, without subjecting the patient to the annoyance of wetting the head all over.

The neck, spine, and abdomen should be treated in all cases, except during the first and tentative applications, or in patients of very unusual susceptibility. During menstruation it is usually better to avoid the abdomen and lower part of the spine, or to suspend the treatment altogether, except in those cases where it is desired to increase the menstrual flow.

Length of the Applications.—The duration of the sittings *may range between five minutes and a half or three-quarters of an hour,* being modified by the nature of the constitution, the strength of the current employed, the stage of the treatment, and the results of the previous applications.

The smallest fraction of this time should be devoted to the head, the largest to the spine; next to the spine the abdomen should receive the largest share of attention.

Experimental applications should always be short; but patients who have long been accustomed to the treatment may sometimes receive most powerful currents, over any portion of the body except the head, for an hour at a sitting, not only without injury, but with positive benefit.

Real or apparent strength of constitution is a very deceptive criterion by which to determine the length of the sittings.

1. An average application of say 15 minutes may be thus apportioned:

To the head	1	minutes.
" neck, sympathetic and cervical spine	4	"
" back	3	"
" abdomen	3	"
" upper and lower extremities	4	"

This is, however, a very general estimate. Each case must be studied by itself. In general galvanization or galvano-faradization the time should be reduced one-half.

Frequency of the Applications.—The applications of general electrization may be repeated daily, every other day, once or twice a week, or by still longer intervals. Every other day is about as often as is necessary to secure the full tonic results of the treatment; but patients who are so situated that they can take the treatment but a short time may receive an application daily, provided they are not in a condition of unusual debility, or are not more than ordinarily susceptible to the current.

Some of our very best results have been obtained on patients who have received applications daily, and for a number of weeks in succession.

It is not well, however, to give thorough applications every day at the outset of the treatment, unless by previous experience we have become acquainted with the constitution of the patient. For the very nervous and susceptible, and especially for those who complain of the secondary or reactive effects, it is often necessary to give intervals of several days, at least until the permanent tonic effects begin to be developed.

Patients who are peculiarly susceptible to other tonics are also susceptible to general electrization, and accordingly need longer intervals than usual between the *séances*.

Persistence in the Treatment.—For the majority of cases, the treatment by general electrization, in order to secure its full results, must be *persistent*. The reasons why this perseverance is demanded are quite obvious. In the *first* place, most of the diseases and morbid conditions for which general electrization is indicated are exceedingly chronic in their character. It is necessary ever to keep in mind the emphatic words of the great Trousseau, "Chronic diseases demand chronic treatment," whatever may be the method employed.

It is a law of disease, that morbid states which have long been in progress must be correspondingly long in their recession; and to this law diseases treated by general electrization cannot present any exception.

Secondly. Tonic remedies of all kinds, external and internal, are always more or less slow in their action.

While great and beneficial effects are often derived from two or three applications, a complete or approximate cure of long-standing morbid conditions, such as dyspepsia, hypochondriasis, nervous exhaustion, hysteria, paralysis, can only be achieved by persistent treatment, varying the strength of the current and frequency of the applications according to the progress which is made.

The length of time over which the treatment should be extended may range from one week to several months, with longer or shorter intervals, according to circumstances. *Intervals* of one or more weeks should be occasionally allowed in all protracted cases when the sittings are held as often as every other day. It is sometimes observed that patients recover more rapidly during these intervals than while the treatment is in progress.

It is needless to say that mild and recent attacks are often dissipated by one, two, or three applications.

Comparing the history of all of our cases, we find that the average number of applications administered to each successful case is about 10–15, and the length of time over which the treatment was extended 3–6 weeks.

The Use of the moistened Hand as an Electrode to the Head and Sensitive Parts.—The advantages which the moistened hand sometimes possesses over the sponge in general *faradization* are the following:—

1. *In certain cases it is more effective.* It is but a truism to assert that no form of electrode that human skill shall ever devise can ever compare with the hand in flexibility and power of adaptation. Its shape, its flexibility, the number and arrangement of the fingers, and the vast and delicate combinations of movement of which they are so readily capable—all these familiar and wonderful characteristics of the hand, united to the peculiar softness

of the skin, and the lightness with which it can touch, or press, or handle, render it superior for the nicer processes of general electrization to any artificial arrangements of which the genius of man could conceive.

It is oftentimes more effective as an electrode than the sponge, partly because it allows of the use of a stronger current with less pain, and partly because the fingers can press firmly but painlessly by the borders of muscles, along the nerve-tracts, and over minute " motor points " of the surface, where the simple mechanical pressure of the metal or sponge would be intensely disagreeable.

2. *It is more agreeable to the patient.* For applications to the head and sides of the neck, the brachial plexus, stomach, and even the arms, the use of the hand electrode is a very great convenience; and we not unfrequently meet with patients who are so sensitive and so fearful that they will not endure even the softest sponge on any portion of the body, or at any stage of the treatment. To apply a mild faradic current to the forehead and crown of the head, with the softest sponge and largest possible surface, is at best an unpleasant process for a strong man in perfect health, and for the delicate invalid is often unendurable; but when the hand of the operator is made an electrode, the operation of faradizing the most sensitive portions of the head may be made not only tolerable, but positively agreeable. The same principle applies, to a less degree, to applications to the neck, face, brachial plexus, nerve-tracts of the arm and stomach. Except in cases of severe local disease or unusual debility, the sponge can be borne down the spine, over the abdomen, and down the lower extremities without great difficulty. Yet even to this rule there are exceptions.

3. *It keeps the operator continually informed of the strength of the current, and thus enables him to carefully graduate it, according to the sensitiveness of each locality.*

As the current passes through his own person the operator can judge, by his own sensations, whether it is too strong or too weak, and, by increasing or diminishing the grasp of his other hand on the sponge, can modify the strength of the application without disturbing his apparatus.

The use of the hand as an electrode enables the operator to instantly modify the applications in any of the various degrees of weakness and strength, and also to suspend the passage of the current instantaneously without shock or violence.

That most, if not all, of the tonic effects of general electrization can be obtained in perhaps the majority of patients by the use of the sponge, there can, we think, be no question; but the use of the hand of the operator, according to the principles above indicated, enables us to achieve these results, and with less discomfort to the patient, in those peculiarly sensitive cases where the artificial electrode could not be borne at all. Very many of our patients we treat only with artificial electrodes.

To sum up, in a word, it is a convenience and oftentimes a positive assistance for the operator to be able and willing to use his hand in applications to sensitive parts and nervous patients, but for the majority of cases it is sufficient to use a large soft sponge. In general galvanization or galvano-faradization the hand is never employed.

Effects of the Current on the Operator.—When the operator uses his one hand as an electrode the current must pass through his person, that is *through his arms and shoulders*, from the hand which grasps the sponge to the one which is applied over the patient.

The power to maintain perfect control of the hands and fingers against the force of a strong current is only to be acquired by long and persevering practice. The mild current that is used for the head and very sensitive patients any operator can easily bear.

The question now arises, What effect must the operator experience from the repeated passage of the electric currents through his own person?

It should be understood, at the outset, that the current does not directly affect the *whole* person of the operator, nor indeed any of the prominent organs, and that only the faradic current is used in this way. The current passes from hand to hand, through the arms and shoulders, and does not reach or directly influence the brain or any of the organs of the chest or of the abdomen. The neck and shoulders constitute a wide pathway through the moist tissues, of which the currents become so diffused that they affect the parts but feebly.

Reasoning, then, from theory and probability, it would seem that the effect of the current, when it thus passes through the body of the operator, must be chiefly felt in the muscles of the arms and but very slightly on the general system.

These deductions of theory are confirmed by experience.

The temporary effects experienced by the physician who employs general faradization to any *great extent* through his own person, are :—

Increase in the rapidity of the circulation, and slight weariness or exhaustion, sometimes accompanied by perspiration.

The secondary or reactive effect is a feeling of soreness in the wrists and muscles of the arms. This is caused by the vigorous and repeated muscular contractions that are produced by the current, and is the same in kind with the general soreness that is experienced by the patient at the outset of the treatment. It is not usually felt from mild currents, such as are applied to the head, and after a few weeks of daily practice it is no longer observed.

This effect is nearly the same as that which is experienced after gymnastic or other muscular exercise. Within certain limits it is exhilarating and refreshing, but by treating a large number of patients in succession in this way, it is possible to become excessively wearied.

The *permanent* effects of the current on the person of the operator are :—

1. *To cause very marked and sometimes rapid growth of the muscles of the arms.*

The explanation of this phenomenon is sufficiently easy. The muscular contractions that are produced by the current in its passage through the arms cause increase of the local processes of waste and repair, and accordingly the muscles increase in size, just as they naturally do under the influence of any other form of active or passive exercise. This mechanical explanation would be of itself sufficient, but, in addition, it is entirely probable that the electric current exercises a direct and specific influence on the nerve branches, which effect is expressed by the increased size and vigor of the muscles through which the nerves ramify.

In our own persons this development of the muscles of the arms has been so very decided as to surprise both ourselves and our friends. It began to force itself on our attention a few weeks after we commenced to give special attention to general electrization, and at the present time it is fully as marked as ever. Both arms of each one of us have not only increased much in size by actual measurement, but also correspondingly in strength and hardness. This effect is observed in the arm and forearm, but most decidedly in the muscles which, from their position or nerve supply, contract most readily and vigorously when the current passes from hand to hand—such as the deltoid, brachialis anticus, biceps, and the flexors and extensors of the forearm. This same effect has been noticed, to a greater or less degree, by our students, and, so far as we have been able to ascertain, by others, who have employed electricity through their own persons for any considerable period. This development of the arms seems to progress up to a certain limit, at which it remains.

2. *A very gradual but decided tonic influence on the system.* This effect is so exceedingly slight, that in a very hardy and vigorous person it would not be recognized. That the current, in passing from hand to hand so frequently and so long, should, in the course of time, mildly affect the general system, is entirely probable. Like any other muscular exercise of the arms—gymnastics and the use of the clubs—its influence, so far as it goes, must be positively toning and beneficial to the constitution.

Still further, it is probable that even the faradic current, widely diffused and weakened as it must be, when it reaches the neck and shoulders, may yet affect, in a very gentle manner, and to an exceedingly limited extent, that portion of the sympathetic and central nervous system through which it must pass.

Whether we account for this slight improvement in the general health of the operator, who thus allows the current to pass through his person by any *one*, or, as is most rational, by *all* of these theories, the settled fact remains that such effects have been practically demonstrated in a number of cases. This slight improvement is observed only for a few months ; like the increase of the muscles, it reaches a limit beyond which it does not pass.

It also seems equally clear that the operator is not usually, if ever, injured by employing the current through his own person. As already remarked, we observed at first in our own persons slight though decided benefit, and since that time we have been able to trace no injurious results.* Two or three instances have been brought to our notice where injurious results were supposed to have been produced by long-continued use of powerful faradic currents through the person. The evidence, however, was rather unsatisfactory, and yet it is not improbable that certain temperaments might be injured in this way.

We have spoken in detail of this part of the subject, not because we regard it as indispensable for success in general electrization that the current should pass through the body of the operator, but because the effects here described so clearly demonstrate the power of the faradic current over nutrition. The majority of practitioners who use general faradization, will either not pass the current through their own persons at all, or will do it so seldom that the effects on themselves will be of a negative character.

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* Wm. Miller, of this city, a gentleman of the utmost reliability, informs us that for over twenty-five years he has allowed the current to pass through his body on an average about five hours each day. When he began his experiments with this system of treatment he was in comparatively feeble health, but during nearly all this long period his general condition has not only been exceptionally sound, but he seems to have been positively improved. Very few of his contemporaries have been so little interrupted by ill health of any form, and he has suffered from no disease that could be even remotely ascribed to electricity.

CHAPTER X.

EFFECTS OF GENERAL ELECTRIZATION.

THE stimulating tonic effects of general electrization may be subdivided into *three* classes :—

1. Those which are experienced during or immediately after treatment.—*Primary or stimulating effects.*

2. Those which are experienced one or two days subsequent to the treatment.—*Secondary or reactive effects.*

3. Those which remain in the system as a permanent result of treatment.—*Permanent or tonic effects.*

Many patients, perhaps the majority, experience after each *séance*, a *feeling of enlivenment and exhilaration*,* that often lasts for several hours. With some this feeling of exhilaration is very positive and decided; with others it is but just perceptible. Others, again, experience a disposition to sleep after treatment, quite similar to that which is felt after a bath in the surf.

These effects are by no means constant. Some patients—even those who experience the *secondary* and *permanent* effects of general electrization to their fullest extent—do not observe any temporary enlivenment or drowsiness; or at least any more than would naturally be felt from the exercise of undressing and dressing, or from the friction of the hand or sponge over the surface of the body.

Relief of pain and local or general weariness is a very frequent as well as very agreeable temporary effect of general electrization, and one which, more perhaps than any other, tends to inspire the doubting patient with confidence in the efficacy of this method of treatment. Patients who suffer from indefinable nervous pains in the head, back, side, and stomach, or from weakness in the limbs, frequently appreciate relief even in the midst of the application. This relief usually lasts for several hours, and in some cases may become permanent.

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* On account of this temporary hypnotic effect of general electrization, it is oftentimes well to employ it, especially on patients who are greatly troubled with insomnia, in the evening, a little while before retiring.

But all these temporary effects of general electrization are variously modified by the age, the nature of the constitution, the condition of the system, the character of the disease, the quality of the current used, and the length of the application. Sensitive patients are sometimes, in exceptional cases, so completely overpowered even by a gentle application, that they desire at once to recline on a lounge. In some very exceptional cases, this *sensation of faintness*, especially when felt at the outset of the treatment, is probably more the result of the mental impression from exaggerated ideas in regard to the return of the applications, than of the current itself. These sensations of faintness and weakness, however, are very exceptional—even with nervous patients are but temporary, and can always be avoided by proper caution.

Cold perspiration on the hands and feet, shaking of the limbs or of the whole body, are *occasionally* observed during or immediately after an application of general electrization. They are observed only in the very sensitive or nervously exhausted, or in those suffering from severe central disease. The occurrence of the former symptom may be regarded as diagnostic of heightened nervous susceptibility, that may or may not be dependent on organic disease of the central nervous system. It is observed in hysteria, nervous dyspepsia, and nervous exhaustion, and disappears as the patient grows stronger and more accustomed to the treatment. Shaking of the limbs or of the whole body only occurs in serious central diseases. It is observed in hemiplegia and softening of the brain, and is always a bad symptom.

Unpleasant effects are more likely to occur from the galvanic current than from the faradic. Giddiness, vertigo, faintness, headache, and symptoms of cerebral congestion may appear after the galvanic current has been applied to the head or neck, especially if the current has been strong, or the application too protracted. These symptoms are sometimes felt instantaneously as soon as the pole of the galvanic current touches the head or neck, but are rarely experienced when the same current is applied to other portions of the body.

All these disagreeable symptoms so arising from an injudicious application, like similar effects from injudicious use of other tonics, physical exercise, the shower-bath, etc., are not usually of any permanency whatever. Indeed, they are entirely consistent with permanently good results; but they are apt to annoy and alarm the patient, and for that reason, if for no other, they should be avoided.

The *Temperature* may be immediately influenced by general electrization.

Its effect on the circulation seems to be that of an *equalizer*. Patients afflicted with nervous diseases are apt to suffer from cold feet and hands, and from creeping chills over the body. The equalizing, warming effect of general electrization on such patients is most decided and agreeable, and is so positively realized, even in the midst of the *séance*, that neither the bare feet nor the exposed trunk suffer from the cold, provided the air of the operating room is of even a moderate temperature.

The effects of general electrization on the pulse are quite interesting and suggestive.

In a large number of cases we have carefully counted the pulse, and also observed its quality just before and just after the treatment. The results of some of these observations are presented below :—

	Before the Application.	After the Application.
1	60	60
2	77	76
3	88	80
4	74	80
5	60	75
6	82	84
7	80	76
8	76	84
9	80	84
10	101	90
11	115	100
12	68	80
13	104	100
14	68	80
15	70	73
16	106	102
17	72	60
18	72	67
19	74	70
20	68	76
21	72	66
22	74	62

On account of the recognized susceptibility of the pulse, especially of nervous invalids, to the influence of mental impression, we have found it necessary, in order to avoid error, to make repeated examinations before and after the sitting.

The conclusion, from our very large number of observations in regard to the influence of general electrization on the pulse in chronic diseases, is that the general action of the pulse is that of a sedative.

When it is high it depresses it more or less, and usually in proportion to the degree of the exaltation above the normal standard. When it is low it raises it more or less, and usually in proportion to the degree of the depression below the normal standard. In nervous and excitable patients, the effect of general electrization on the pulse is much more marked than in the cold and phlegmatic.*

The immediate effect on the appetite is, in rare instances, so marked that the patient at once feels desire for food, and at the next meal eats a much larger quantity and with far keener relish than usual.

Sensitive patients are now and then compelled to evacuate their bladder or rectum immediately after or even in the midst of the application, and the urinary secretion is occasionally increased.

But all these effects of general electrization on the functions of special organs are incidental and occasional, and are not to be expected with any uniformity or constancy. Weariness of certain parts, as the eye, brain, spine, and muscles, is usually more or less relieved.

Secondary or Reactive Effects.—The *secondary* or *reactive* effects of general electrization are those which are experienced *for a day or two following an application.* These effects are probably not observed in more than half of the cases, and usually only at the outset of the treatment.

Soreness in the muscles of the neck, trunk, and upper extremities is unquestionably the most frequent of the secondary symptoms of general electrization, and the one which patients are soonest to observe and describe. This muscular soreness is quite similar to that which is so commonly felt after taking a slight cold, or after exercising in the gymnasium. It is the result of the muscular contractions that are produced by the electric current. They usually pass off in two or three days, and are scarcely observed at all after the patient has once become accustomed to the treatment. By making the first tentative applications gentle and short, it is possible to avoid entirely this subsequent muscular soreness, and in very feeble or very timid patients we should always endeavor to do so.

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* Comparing general faradization and galvanization of the sympathetic in their effects on the pulse, on sleep, and on the circulation, it would appear that in the former method the *sympathetic* and pneumogastric must be decidedly affected. (See chapter on Sympathetic.)

Indefinable *nervousness* is another occasional secondary effect of general electrization, and one that often gives rise to idle and unnecessary alarm. Like the soreness of the muscles, it usually passes off in a day or two, and is not commonly experienced after the patient has become accustomed to the treatment.

Weariness and exhaustion may be experienced by this class of patients for several days after an injudicious application. It is a very interesting and important fact, that these annoying *secondary* symptoms of weariness and exhaustion are oftentimes experienced to their fullest extent by patients on whom the *immediate effects* for a few hours succeeding the application are only agreeable. On account of this fact, the inexperienced electro-therapeutist may be unpleasantly deceived, and from the temporary enlivenment of his patient may suppose that his application has been thoroughly successful, until the distressing secondary effects, continuing perhaps for several days, show most clearly that it has been either too strong or too protracted.

Exacerbation of special symptoms—such as neuralgia, headache, insomnia, etc.—may sometimes secondarily ensue from an overdose of general electrization.

Although it is proved by experience that such unpleasant results only temporarily interfere with the final success, yet their occurrence powerfully tends to discourage the patient, and should therefore be avoided by making the first applications short, and with a mild current. In one very intelligent patient the symptoms were so marked that he supposed the application caused him to take cold.

Permanent or Tonic Effects.—To designate any precise time or stage of the treatment when these tonic effects are to be looked for, is manifestly impossible. Like the tonic effects of other analogous internal or external remedies, the time of their appearance must be variously modified by the nature of the disease, the constitution of the patient, and the skill and perseverance of the treatment. They may appear early in the treatment, developing themselves with great rapidity; or they may remain latent until after the applications are abandoned, and then advance with sure and steady progress. They may be so rapidly manifested at the commencement of the treatment as to cause us to suspect them to be more the result of mental impression than of the applications; and, on the other hand, they may develop themselves so long after the treatment as to suggest the doubt whether they are not as much due to nature and time as to the direct electric influence.

Among these tonic effects of general electrization, those which chiefly attract the attention and are of the principal importance are the following:—

Improvement in the Sleep.—This symptom comes first in our analysis of the permanent effects of general electrization, because it is one of the first to be appreciated and observed by the patient. As insomnia is the most constant and universal symptom of those various nervous conditions for which general electrization is indicated, just so is its relief or cure the first and leading evidence that the treatment is having its desired effect. As already mentioned, inclination to sleep is one of the *immediate* symptoms of the applications, and may come on even in the midst of the séance; but the improvement in the sleep of which we here speak, as a *permanent* effect, is appreciated during the intervals of treatment, and long after it has been suspended.

The importance of improvement in the sleep for nervous invalids cannot, of course, be over-estimated. Sleep is food for the nerves. To a limited extent it supplies the place of ordinary food, and that too without taxing the organs of digestion. It is an exceedingly suggestive and pleasing fact, that insomnia, which is so often the earliest and most persistent symptom of nervous disorder, should also receive the earliest and most permanent relief from general electrization.

Increase of Appetite and Improvement in Digestion.—Increase of appetite and improvement in the digestion is not so early nor as constant a symptom as improvement in the sleep.

In exceptional cases it may be due entirely to the direct effect of the current on the stomach and pneumogastric nerve, and for that reason it is always well, in cases of dyspepsia, to give special attention to these parts; but in the majority of instances it is the result of the general tonic impression made on the whole system.

It is by no means a constant or uniform effect, even in those cases where it would seem to be needed, and where, too, in all other respects, great and lasting benefit is derived from the treatment. Some patients who are permanently relieved of neuralgia, of insomnia, and of muscular and nervous debility, yet observe no decided improvement in their digestion. Such cases, however, are quite exceptional.

Regulation of the Bowels.—Constipation sometimes yields very early in the treatment. The temporary effect is probably due, in many instances certainly, to the direct mechanical action of the current on the intestines; but permanent relief, either of constipation or of diarrhœa of the nervous variety, is not to be expected until the indigestion and general debility on which they depend have first been corrected.

Improvement in the Circulation.—Permanent equalization of the circulation is most observed in cases of dyspepsia, nervous exhaustion, hysteria, and similar conditions with which defective circulation is so frequently associated. It is then the result of the improvement in the assimilative power and nutrition of the system.

In paralysis caused by central lesions, the permanent improvement in the circulation is usually slow, but almost always quite decided.

Relief of Nervousness and Mental Depression.—The indefinite, though very well recognized, condition which we term nervousness, and the indefinable mental agony that forms so prominent and so distressing a symptom in hypochondriasis, hysteria, dyspepsia, exhaustion, and other nervous conditions, yield to general electrization more surely and rapidly than to any other method of treatment with which we are familiar.

Relief of nervousness is sometimes observed quite early in the treatment.

These symptoms of nervousness and mental depression are very apt to occur even in the midst of a course of treatment, but by long perseverance are oftentimes entirely dispelled.

The remarkable ease and success with which general electrization relieves, at least for a season, the horrible depression of nervous invalids is sufficient to entitle it to a foremost rank among tonic remedies.

Relief of Weariness and Pain.—Permanent relief of pain as an effect of general electrization is most markedly observed in the constitutional varieties of neuralgia.

Not only well-defined neuralgia, but the indefinite, wandering sensations of uneasiness that accompany dyspepsia and nervous exhaustion, may be permanently driven from the system.

Patients who are suffering from some organic disease, that is in its very nature incurable, and that has reduced the system to a condition of great exhaustion, may sometimes be greatly invigorated by general electrization, without experiencing any decided relief of their pains. But in such cases the strength which the constitution acquires from the treatment fortifies the patient to endure suffering with less annoyance, and therefore practically amounts to a diminution of pain.

This effect is observed in certain incurable forms of neuralgia, in cancer, and other malignant tumors.

Increase in the Size and Hardness of the Muscles, and in the Weight of the Body.—This is a natural result and accompaniment of the improvement in nutrition, and that it follows the use of the faradic as well as of the galvanic current, sufficiently demonstrates that power over nutrition is not confined to the latter.

Under the influence of protracted treatment by general electrization, the muscles are sometimes developed in size as well as in firmness to a degree which very naturally astonishes those who, for the first time, have their attention directed to it. This increase in size and quality of the muscle is, of course, chiefly observed in those portions of the surface of the body where, under the influence of electrization, contractions are most easily produced. Therefore we first look for this effect in the arms, the legs, and afterwards in the chest. This effect is soonest observed in patients who are comparatively thin, or, at least, whose muscular tissue predominates over the adipose. On the other hand, and for obvious reasons, it is quite rarely perceptible in children, in females, or in the very corpulent of either sex.

Under general electrization ***actual increase in the size and weight of the body*** sometimes takes place so rapidly and perceptibly to the eye that it need not be confirmed by reference to the scales. In other cases, where patients, either through curiosity or accident, have carefully weighed themselves just before taking a course of treatment, a most remarkable increase of weight has often been observed in the course even of a few weeks.

This increase of weight is simply a result of the effect of the electric currents on nutrition, and a natural sequence of the improvement in the sleep, the increase of appetite, and the relief of pain and mental depression, of which we have already spoken.*

Increased Disposition and Capacity for Labor of the Muscles and of the Brain.—Whatever tends, directly or indirectly, to improve nutrition must of necessity increase the capacity for intellectual and muscular toil. Accordingly we find that patients who were so feeble that even a short walk or ride was fatiguing, and who were signally deficient both in the will and the capacity for exertion, soon begin to develop, under treatment, an activity and vigor that is sometimes surprising. They can walk farther and more vigorously, and with greater enjoyment. They realize a consciousness of strength to which before they were strangers, and feel emboldened to exertion from which they would formerly have shrunk with apprehension.

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* Legros and Onimus make the very just criticism on the unsuccessful experiment of Mons. Bert, that they rationed the animals on whom they experimented. Increase of appetite that ensues from electrization, and all the accompanying stimulation of the vital processes, will be of little avail in the improvement of nutrition unless sufficient food is supplied to meet this increased demand.

These bracing effects are even more perceptible on the brain than on the muscles.

Many who are badly dyspeptic and thoroughly neurasthenic are yet capable of severe and prolonged muscular exercise, can toil in the gymnasium or walk all day without fatigue, and desire treatment chiefly for their indisposition and inability to concentrate their mind on any given subject, or for uncertainty of memory. The benefit which such patients receive is fully as marked as that which accrues to those who suffer from muscular debility. Patients find that they can read with closer attention and with greater zest; that they can pursue connected thought without fatigue, and endure mental toil and anxiety that was once intolerable.

The cases of general debility where none of these permanent tonic effects of general electrization are realized are very rare indeed, and those that we do occasionally meet with are probably to be accounted for by some hidden but persistent organic condition that has escaped our diagnosis, but which exerts on the system a constantly depressing influence that more than counteracts the tonic effects of the treatment.

The genital organs are frequently corrected in their functions by general electrization. These organs are so intimately connected with the vital parts of the system by means of the ganglionic nerves that they must necessarily share in all the good or evil effects that the spine or the body receives.

All will agree that impotence and weakness of sexual power in the male, and amenorrhœa, dysmenorrhœa, and menorrhagia in the female, are frequently associated with and may be the *results* of spinal or constitutional debility. We should therefore expect that these diseases, or symptoms of disease, would be greatly benefited by the tonic effects of general electrization.

Male patients sometimes report increase of sexual power even when no special attention is given to the genital organs. The testicles and the penis are, however, directly affected through their nerve-supply by applications to the lower portion of the spine. The same is true of the female genital organs and ovaries in the female.

Cases of weakness or exhaustion of the eye or larynx in nervous patients, where the ophthalmoscope and laryngoscope indicate no lesion, are sometimes permanently relieved during the treatment.

Concerning these tonic effects it is to be observed—

1. *They are not uniform.* They vary not only with different individuals and diseases, but also with the same individual at different periods of life. In some patients these effects are only felt so long as they are under treatment—they become, in a measure, dependent on it; in other cases the effects are not appreciated in their fulness until long after the treatment is abandoned.

2. *They are more rapidly appreciated by the active and the nervous than by the cold and phlegmatic.* Other conditions being the same, a sensitive, impressible organization will recover more rapidly under general electrization than one of an opposite temperament.

3. *They are usually as lasting and permanent as similar effects from other remedies and systems of treatment.* It is true that patients who have been apparently cured by general electrization are subject to relapses, yet to no greater and apparently to a less extent than those who have derived similar relief from internal medication. In considering this statement, regard should be had to the fact that the diseases for which general electrization is chiefly indicated, at least those in which it has thus far been most successful, are those which are most likely to relapse under any or all forms of treatment.

Rationale of the Effects of General Electrization.—General electrization is to the whole body what localized electrization is to an individual part or organ. All the mechanical, electrotonic, and catalytic effects, with the consequent increase of the processes of waste and repair and improvement in nutrition that electrization is capable of producing in the living tissues (see p. 83), and which, in exclusively localized applications, are mainly confined to the part which is traversed by the current, are in general applications appreciated by every part of the system. Then, again, the improvement which each part or organ receives from the treatment reacts upon every other part and organ. Every effect becomes in its turn a cause; the strengthened brain sends more nervous force to the stomach, by which the latter is enabled to send better blood to the brain.

Comparing what is known of the conductibility of the tissues, and the action of the electric currents upon them, with the observed effects of general electrization, these effects may be regarded as due mainly—

1. *To the fact that the entire central nervous system* is directly influenced by the current. In an ordinary application the brain, spinal cord, and sympathetic ganglia are all subjected to the electrotonic, or catalytic action of the current. In most of the applications of central localized electrization only a part of the central nervous system is affected at each sitting. We are warranted in believing that in nearly all nervous diseases the central nervous system is in a condition of greater or less exhaustion, even when it is not organically diseased. According to Du Bois-Reymond, there is always present in the spinal cord a current of animal electricity. It is not unreasonable to suppose that this current may become diminished or disturbed through local or constitutional disease, and that it may be increased or corrected by the application of an electric current through the cord. Whether this increase or correction of the current of animal electricity takes place directly or by the transformation of nervous force into electricity,* just as in electric fishes nervous force is transformed into electricity,† is immaterial. These remarks may apply just as truly to the brain and sympathetic ganglia. General electrization also produces analogous effects on a large portion of the peripheral nervous system, although with far less important results, because a majority of chronic nervous diseases are associated with some form of central disturbance.

2. The passive *exercise that results from the vigorous and repeated muscular contractions produced by the applications.* When

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* On the Relation of Electricity to Nervous Force, see page 90.

† Herbert Spencer's Principles of Biology, vol. i., pp. 48, 49.

the applications are thoroughly and skilfully made; vigorous yet agreeable contractions are excited not only in all the superficial muscles, but in the deeper layers, and also of the contractile fibre-cells of the stomach, the intestines, and other vital organs. The augmentation of the manifold processes of waste and repair which a single sitting causes in the muscles and abdominal organs would alone powerfully influence nutrition, even though the electric current exerted no direct effect on the nervous system.

That the tonic effects of general electrization are very largely due to the passive exercise which it produces is proved clinically by the fact that when a current too feeble to cause muscular contractions is used, or when the muscles are neglected, the tonic as well as the primary effects of the treatment are much less marked.

CHAPTER XI.

DIFFERENTIAL INDICATIONS FOR THE USE OF LOCALIZED AND GENERAL ELECTRIZATION.

In order to determine the differential indications for the use of localized and general electrization we need to consider these four facts :—

First, That general electrization *directly* affects the whole body, while in localized electrization the direct action of the current is mainly confined to the part to which the application is made.

Secondly, That general electrization may, by sympathetic or reflex action, *indirectly* have a special therapeutic influence on some *special* part or organ,* while localized electrization of any part, but especially of the sympathetic or cerebro-spinal axis, by sympathetic or reflex action, may *indirectly* have a *general* therapeutic influence on the whole body.

Thirdly, Electrization, when properly performed, very rarely injures, and usually more or less benefits, even those parts which are in comparative or absolute health. This consideration has an important practical bearing, especially in the use of general electrization, in cases of doubt as to the seat of the disease.

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* Brown-Séquard and Lombard (Archives de Physiol., November and December, 1869) have shown that when one arm is pinched the temperature of that arm slightly rises, and that of the opposite arm falls. Dr. James J. Putnam (Boston Medical and Surgical Journal, June 23, 1870) has shown by a series of experiments on frogs that electrization of one foot caused reflex contractions of the blood-vessels in the web of the foot of the opposite side. These experiments, taken in connection with the fact that nutrition is closely related to circulation, would render it clearly probable that reflex action is an important factor of the results of application of electricity, and especially of general electrization, where the extremities are directly affected by the current.

Fourthly, In nearly all cases it is important, and in many it is indispensable, that the applications should be made to the seat of the disease as well as to the locality of the symptom. Scientific electro-therapeutics, therefore, requires the most accurate preliminary diagnosis; above all, it is important to rigidly discriminate between diseases which are of a constitutional and those which are of a local (that is central, peripheral, or reflex) origin.

From these fundamental considerations we logically derive the general law that ***constitutional diseases are better treated by general, and local diseases by localized electrization.***

More specifically, experience demonstrates that of those large variety of diseases for which applications of electricity are found useful, localized electrization is specially and *exclusively* indicated.

1. In those cases where both the origin, the seat, and the effects of the disease are restricted to certain portions of the organism, with but slight or imperceptible influence on the system at large. Under this head are included nearly all peripheral and many central and reflex paralyses and neuralgias, effusions, sprains, and local injuries, and also many of the diseases of the eye, ear, larynx, and genital and digestive organs.

2. Localized electrization is indicated, though not always exclusively, in those morbid conditions for which galvanization of the cervical sympathetic has been found to be of service. Of the diseases which come under this category, those which yield more surely to galvanization of the sympathetic than to any other method of electrization are paralysis of the sympathetic, muscular atrophy, arthritis nodosa, certain forms of cerebral hyperæmia, and disorders of the vaso-motor nerves.

3. Localized electrization, in both central and peripheral applications, may frequently be alternated with general electrization in very many of the diseases for which this latter method is chiefly indicated. In nervous dyspepsia, chlorosis, hypochondriasis, constitutional paralysis, and neuralgias, rheumatism, chorea, and functional diseases of special organs, it is sometimes of advantage to use galvanization of the brain, the spine, sympathetic, and the pneumogastric, and peripheral galvanization or faradi-

zation a certain portion of the time, although this method alone is far less satisfactory in these diseases than general electrization. A prominent illustration is found in those paralytic conditions, attended with great diminution or entire loss of electro-muscular contractility, where localized applications are more efficacious to produce muscular contractions than general, although they do little or nothing toward removing the morbid constitutional condition of which the paralysis is but a symptom.

On the other hand, general electrization is indicated—

1. In those diseases that are dependent on or associated with impairment of nutrition and general debility of the vital functions, such as nervous dyspepsia, neurasthenia, anæmia, chlorosis, hysteria, hypochondriasis, paralysis, and neuralgia of a constitutional origin, rheumatism and other toxic diseases, some forms of chorea, and oftentimes in functional disorders of the genital, digestive, and other special organs.

2. In morbid symptoms dependent on some local cause which cannot be satisfactorily diagnosticated. It must be confessed that a large number of cases of chronic diseases are frequently dependent on or connected with some important lesions, of which, during the lifetime of the patient, even the most approved methods of diagnosis and the most practised skill utterly fail to ascertain either the nature or the locality. This is oftentimes the case with neuralgia, with paralysis, epilepsy, hysteria, and hypochondriasis; sometimes, also, with affections of special organs, as the eye, ear, larynx, and uterus.

Benedikt emphatically affirms that electricity should be applied almost exclusively *in loco morbi*, in the place of the disease, and in cases of doubt recommends tentative applications successively in all the suspected localities until the diagnosis is made out by the success of the treatment.* It scarcely need be said that this purely experimental system, though sometimes successful, must be and is annoying, uncertain, and very frequently unsatisfactory.

The advantage of general electrization in such cases of doubtful pathology are twofold: *First*, at each application it affects all parts of the body, and thus is sure to reach the seat of the disease, wherever that may be; and *secondly*, it at the same time improves the general nutrition of the system, which, in such cases, is frequently more or less impaired. This improvement in nutrition, as has been stated, oftentimes reacts favorably on the local disease.

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* Die Electrotherapie. Wien, 1868, p. 79.

Still further, it must be confessed that very many of the diseases in which general electrization is proved to be of most efficient service, are those in which no special *locus morbi* can be found even on *post-mortem* examination.

Future investigations will undoubtedly do much to dispel our ignorance on these points, and will probably assign a definite local cause to some of the diseases which are now vaguely classed as constitutional. But even those diseases in which the local cause is definitely ascertained may demand constitutional treatment as much as or more than those in which no local cause is demonstrated. When a house is set on fire by a burning fuse, it is not enough to snatch away the fuse; we must extinguish the flames. When the nervous system has been thrown into tetanus by a wound in the foot, excision or healing of the wound is of little avail; remedies must be directed to the central nervous system. Precisely so when chronic local disease has enfeebled the vital functions and impaired nutrition, our applications are to be directed to the general system as well as to the seat of the lesion.

3. In certain diseases which, though themselves incurable, are accompanied by impairment of nutrition that is susceptible of more or less relief. Palsy agitans, many cases of cerebral and spinal paralysis, advanced stages of locomotor ataxy, rheumatic gout, epilepsy, and certain spastic affections may be absolutely incurable, and yet the emaciation, nervousness, insomnia, and general feebleness with which these diseases are associated as cause or effect or concomitant, may be susceptible of most grateful relief from general electrization.

Illustrative cases of every grade will hereafter be presented in detail.

A disadvantage of general electrization is that it takes more time and labor than local applications. This objection, however, is more than counterbalanced by the superiority and greater rapidity of the results which, in the conditions above named, it frequently enables us to achieve.

A disadvantage of localized electrization with the faradic current is, that it is frequently more painful than general electrization, for the reason that the smaller size and greater nearness of the electrodes to each other causes greater density of the current at its points of entrance and exit. This disadvantage is not ordinarily of sufficient weight to contraindicate its employment in any case for which it is fully indicated.

The comparison we have here made reveals the cause of some of the failures and discouragements that have been and are now being encountered by many experimenters in the department of electro-therapeutics. Constitutional diseases have been treated locally. Morbid constitutional conditions, such as hysteria, anæmia, rheumatism, and the like, which, as all physicians agree, demand remedies that affect the system, are treated electrically only through their local symptoms, such as peripheral paralysis, or neuralgia, or inflammation of the joints. Temporary relief, or metastasis of these local symptoms may indeed result from exclusively localized applications in such cases, but permanent correction of the morbid condition on which these symptoms depend can only be obtained by general treatment. In subacute rheumatism, for example, galvanization or faradization of an inflamed joint frequently removes the pain and effusion in that joint, and therefore may advantageously be used with general electrization, just as the external application of alkaline solutions may advantageously be combined with the internal administration of the same remedies; but to depend on merely localized electrization in such cases is manifestly as unphilosophical as it would be to depend on merely local applications of alkalies. In general practice it will unfortunately be found that physicians will frequently use localized electrization in cases for which general electrization is indispensable for complete results, for the reason that they have neither the time nor the practice to enable them to use the latter method with success, just as the majority of general practitioners, for want of a galvanic apparatus, are obliged to use faradization in cases for which galvanization is imperatively demanded.

This comparison furthermore reveals and explains the suggestive fact that the sphere of modern therapeutics has, in a measure, corresponded to and progressed with the advance in the method of application. Thus, when peripheral applications were chiefly used, the scope of electro-therapeutics, though important, was narrow, neuralgia and paralysis being the diseases for which it was mainly employed. On the introduction of central galvanization electricity was found to be most useful for many conditions in which previously it had been supposed to be either valueless or contraindicated. The sphere of electro-therapeutics is by general electrization still further extended to embrace a large variety of conditions and indications which localized applications fulfil either not at all, or but very imperfectly.

ELECTRIZATION BY STATICAL ELECTRICITY (FRANKLINIZATION).

Statical Electricity, which, prior to the discovery of the voltaic pile, was the almost exclusive dependence of electro-therapeutists, has been gradually superseded by the galvanic and faradic currents, until, in recent times, it has been employed by only a small minority of those who resort to electricity in the treatment of disease.

The reasons for this almost universal substitution of galvanization and faradization for the use of statical electricity are, these—

1. The apparatus required for the development of statical electricity, as compared with the most recent and improved apparatus for faradization and galvanization, are bulky, inconvenient, and frequently unequal, uncertain, and uncontrollable in their action, being greatly dependent on atmospheric conditions.

2. Statical electricity cannot be as satisfactorily varied in its applications so as to meet the special indications required by different diseases, whereas the galvanic or faradic currents can be used locally or generally, and can be more easily regulated in regard to the dose and direction of the current.

3. The length of time required in some of the methods of using statical electricity would practically prohibit its use, even though there were no other objections.

4. Experience shows that statical electricity, however administered, is comparatively useless in many diseases in which galvanization or faradization is most successful. On the other hand, it is yet to be demonstrated that there are any conditions that are better met by the use of statical electricity than by a skilful use of the galvanic and faradic currents.

Professor Schwanda, of Vienna, has recently revived the attention of the profession to the use of statical electricity by his reports of successes obtained by Holtz's electrophorous machine. (For description, see pp. 16 and 17.) He claims that it produces the same effects in paralysis as the faradic current; that in cutaneous anæsthesia it is more efficacious than either the faradic or galvanic current; that it acts as a general tonic. Something more than these general statements will be necessary to reintroduce statical electricity into practice.

No evidence is adduced to show that its tonic effects are in any way comparable to those which are obtained from general faradization. It is difficult to conceive how it can be more effective in cutaneous anæsthesia than faradization, which is so uniformly successful in this condition that it might almost be called a specific for it. Very few affections yield so readily to any method of treatment as anæsthesia to faradization.

As compared with the faradic current alone, statical electricity would appear to have some advantages in the treatment of simple neuralgia, but as compared with both the galvanic and faradic currents no such advantage is demonstrated.

In spite of all these opposing reasons, statical electricity has continued to be used by a few experimenters even in these eras of galvanization and faradization. Besides Professor Schwanda, above quoted, electricity from frictional machines has been used by Drs. Golding Bird and Gull, in Guy's Hospital; by Dr. Clement, of Frankfort; and in the London Hospital for the Paralyzed and Epileptic, by Dr. Radcliffe and others.

The methods of using statical electricity that are most frequently employed are the *electric bath*, *electrization by sparks*, and *shocks from the Leyden jar*.

The *electric bath* is either *electro-positive* or *electro-negative*.

In the *electro-positive* bath the patient is placed on an insulating stool, holds the prime conductor, and receives the electricity accumulated on the glass plate, while the negative electricity is discharged from the cushions through a metallic chain connected with the ground.

The surface of the body of the patient becomes charged with positive electricity, while the surrounding air is negatively electrified.

It is claimed that during the application the secretions and circulation are stimulated. The patient should take the bath for two or three hours daily.

In the *electro-negative* bath the patient, seated as before on an insulating stool, receives the negative electricity from the cushions, while the positive is discharged from the glass plate through a metallic chain connected with the ground. The cushions must be insulated by glass. It is claimed that the electro-negative bath has a debilitating effect; that it deprives the body of its normal electricity; that it produces effects similar to those that are obtained by bloodletting. The process of "charging the patient" has sometimes a most charming effect in neuralgia.

Electrization by sparks is accomplished by drawing off the electricity from a patient charged in the electric bath by means of some metallic conductor or by the hand of the operator, the conductor or hand of the operator becoming negative and uniting with the positive electricity of the patient with a snapping noise and a flash of light. Electrization by sparks is accompanied by a pricking, stinging sensation, and, when the sitting is protracted, is followed by redness of the skin and a peculiar eruption of white circumscribed wheals. The eruption usually appears in five or ten minutes. It disappears in the course of an hour. Sometimes the sparks are drawn through flannel, the end of the insulated conductor being applied to the flannel, and passed up and down over the region that is to be affected. A rapid succession of sparks may produce vibrations in the superficial muscles. Electrization by sparks has been found efficacious in paralysis, amenorrhœa, and chorea, and many other affections.

Shocks from the Leyden jar are produced by bringing the body, or that portion of it on which we wish to operate, in the circuit between the outer and inner coating. A shock may be sent through the arms and chest by placing one hand on the knob connecting with the inner coating (containing the positive electricity), and the other hand on the outer coating of the jar, containing the negative electricity. A shock may be sent through the pelvis by applying one end of a branched conductor connected with the inner coating to the back, and applying the outer coating of the jar against the hypogastric region. In the same way electricity of the Leyden jar may be localized in any part of the body. The shock produced by the Leyden jar is sudden and disagreeable.

In order to charge a Leyden jar, take hold of it by its outer coating and present the knob connected with the inner coating to the prime conductor of an electrical machine in motion. The inner coating receives positive to the outer coating negative electricity. (See page 18.)

Sparks from the Leyden jar have met with some of their best successes in the treatment of amenorrhœa. Inasmuch as, for reasons above presented, the use of statical electricity is quite limited, being mainly confined to hospitals, it has not been thought necessary to present any elaborate descriptions of the various forms of apparatus that have been employed.

It is sufficient to say that the one which is now in the ascendant is that of Holby, to which we have before referred.

CHAPTER XII.

ELECTRO-PHYSIOLOGICAL ANATOMY.

Electro-Physiological Anatomy treats of the physiological action of muscles under the influence of the electric currents.

The contraction observed in an individual muscle when submitted to the influence of the electric current, closely resembles the contraction of the same muscle when under the influence of the will.

Duchenne was the first to investigate this subject systematically, and his researches have done much to modify the accepted views concerning the functions of certain muscles. Those who desire a more complete idea of his views than is given in the following brief résumé, we refer to his writings.*

Electro-Physiognomy.—This name has been applied to the study of character and expression, through localized faradization of the muscles of the face. By means of small electrodes the current can be localized so as to produce contractions even in the smallest muscles. For these experiments a recently dead subject is to be preferred, because in the living man contractions produced by the current would be complicated and interfered with by involuntary movements.

According to Duchenne, who has chiefly investigated this subject, the *frontalis* muscle, when a little contracted, expresses pleasure; when more contracted, astonishment or doubt; when strongly contracted, with other muscles, terror.

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* De l'Electrisation Localisée et de son Application à la Pathologie et à la Thérapeutique. Paris, 1861 ; also, Mécanisme de la Physionomie Humaine, ou Analyse Electro-Physiologique de l'Expression des Passions applicable à la Pratique des Arts Plastiques. Paris, 1862. This work contains photographic representations of the various appearances of the face under electrization of the different muscles.

Contraction of the *pyramidalis nasi* expresses sadness; of the *corrugator supercilii*, contemplation; of the *orbicularis palpebrarum*, contempt. Contraction of these two, united with the pyramidalis nasi, gives a hateful, malicious expression. Contraction of the *triangularis nasi* expresses lust; of the *zygomaticus major*, various degrees of mirth; of the *zygomaticus minor*, melancholy; of the *platysma myoides*, hypocritical laugh; of the *platysma myoides*, pain. Contraction of the *platysma myoides* and *frontalis* gives an expression of terror. Contraction of the *platysma myoides* and *pyramidalis* expresses rage. United contraction of the *zygomaticus major* and *frontalis* produces an expression of agreeable surprise. Contraction of the *buccinator* indicates age, by making furrows in the cheek.

Contraction of the *levator* alæ and *labii superioris* causes an unpleasant expression, such as a child exhibits when about to cry; contraction of the *triangularis oris* gives an expression of sadness or disgust.

Contraction of the external fibres of the *orbicularis oris* gives the lips a position of whistling or kissing; contraction of the internal fibres of the same muscle compresses the lips against the teeth.

Muscles of the Upper Extremity.—The contractions resulting from electrization of the extensors of the fingers give to the hand a peculiar appearance.

The first phalanges not only become extended, but are spread apart, while the last two phalanges become flexed.

The metacarpus forms an angle with the forearm, and in this condition the hand resembles, to a certain extent, a bird's claw.

Electrization of the extensor digiti minimi proprius separates the little finger from its neighbor, while contraction of the extensor indicis proprius brings the index and middle finger together. By the method of localized electrization the adductors and abductors of the fingers, and the interossei and lumbricales, are found to act not only in drawing these members together and separating them, but also in extending the second phalanx of the thumb and the second and third of the other fingers.

The flexor pollicis brevis is concerned in extending the second phalanx of the thumb as well as in flexing the first.

So long as the arm is in its natural position, the supinator longus has no function to perform; it is only when the forearm is prone that its peculiar action is manifest.

In paralysis of any one of the above muscles, it is readily seen that the observation made concerning their function is correct.

For example: if the abductor longus and extensor brevis pollicis become paralyzed, the metacarpal bone of the thumb is adducted. If the extensor longus pollicis is paralyzed, the thumb is inclined towards the metacarpus, although its movements are not markedly impaired if the extensor brevis and adductor longus are strong.

Electrization of the *deltoid* not only raises the upper arm but also very perceptibly changes the position of the scapula. The external angle of the shoulder-blade becomes depressed, the internal angle is elevated, while the distance between its posterior spinal border and the ribs is slightly increased. In paralysis of the deltoid the arm hangs by the side almost completely helpless. The muscle is composed of three distinct groups of fibres, and the degree of paralysis depends upon the number of groups or special group involved.

The pectoralis major and latissimus dorsi muscles, although situated for the most part on the trunk of the body, are more especially useful in assisting in the movements of the arm.

Muscles of the Trunk.—When all of the fibres of the trapezius are submitted to electric excitation, the shoulder-blade becomes elevated, its posterior border approaches the median line, the shoulders are drawn backward, and the head is thrown slightly forward and toward the opposite side. Like the deltoid, the trapezius is made up of three sets of fibres.

When the superior set is electrized the head turns toward the side irritated, and the face looks towards the opposite side.

The middle set of fibres elevates the shoulder-blade, while by the action of the lower set its inner angle is depressed, and its posterior border is drawn towards the median line. In complete paralysis of the trapezius the following symptoms are manifest:

The back is rendered broader, on account of the scapula removing slightly from the spinous processes ; the shoulder becomes depressed, and, on account of the absence of steady support for the arm, its movements are rendered difficult. Electrization of the rhomboideus major and minor muscles elevates the scapula and slightly turns it on its outer angle.

If the current be sufficiently intense, the lower angle of the scapula approaches nearer to the spinous processes than the inner.

If the rhomboideus muscles are paralyzed, the scapula removes itself somewhat from the walls of the thorax, the skin between the shoulder-blade and the spine appears in folds, and the lower angle of the bone is drawn forward and outward, on account of the action of the serratus ant. maj. By excitation of the serratus anticus major the scapula is drawn forward and outward, so that the space between its posterior border and the spine is doubled. The posterior border is pressed against the ribs, while the anterior border is markedly removed from them.

When the muscle is paralyzed the shoulder-blade sinks but little, so long as the arm hangs motionless by the side ; but as soon as it is moved from the body the posterior border and under angle of the scapula are lifted from the thorax, while the anterior approaches it more closely. In complete paralysis of the serratus anticus the movements of the arm are much impaired.

A single external intercostal muscle may be electrized by pressing a small electrode against the lower border of one of the upper ribs, near the origin of the serratus magnus muscle.

The individual abdominal muscles are readily influenced by electric excitation.

Electrization of the rectus muscle so stretches and draws it inward that the abdominal wall becomes flat. Irritation of the external oblique expands the abdomen laterally.

If we electrize the transverse abdominal, powerful transverse contractions of the abdomen follow. When both phrenic nerves are submitted to electric excitation, powerful and frequent contractions of the diaphragm are produced. An increased amount of air rushes into the lungs, on account of the capacity of the thorax enlarging through the descent of the diaphragm, and the moving outwards of the false ribs. Atrophy of the diaphragm causes, during inspiration, a depression of the epigastrium and abdominal walls, while the thorax expands as usual.

Muscles of the Lower Extremities.—Electric excitation reveals the fact that flexion and extension of the foot cannot be produced by the flexor or extensor muscles alone, since these muscles tend to abduct and adduct as well as flex and extend. The flexors and extensors cause direct flexion and extension only when they act in conjunction with certain other muscles.

Duchenne found that the movements of the foot were controlled by four sets of muscles. These are :—

The tibialis anticus, which at the same time flexes and adducts the foot, he termed the flexor adductor muscle ; the extensor digitorum communis longus and extensor hallucis, which flex and abduct the foot, the flexor abductor.

The gastrocnemius solius and tibialis post. extend and adduct the foot ; these muscles he called the extensor adductor ; and the peroneus longus and brevis, which extend and abduct the foot, the extensor abductor.

Electrization of the tibialis anticus, or, in other words, the flexor adductor muscle, not only extends and adducts the foot, but lifts the inner border of its upper portion as well.

Electrization of that group of muscles called the flexor abductor, besides flexing and abducting the foot, extends the four last toes, lifts the outer border of the foot, turns the sole outward, and bends the great toe.

In many cases of partial paralysis of the lower extremities, the foot is observed to turn outward and to strike the ground at every step in walking. Finally, pes equinus may result from the stronger action of the extensors.

If the flexor abductor group become paralyzed the movement of the foot is reversed—the sole turning inward and the anterior portion turning upward.

Electrization of the extensor adductor group so extends and *adducts* the foot that the heel is directed outward and the great toe inward. The first phalanges of the toes become extended, and the last flexor, giving to them the form of claws.

Electrization of the extensor abductor so extends and *abducts* the foot that the internal malleolus becomes decidedly prominent through the sinking of the inner border and the elevation of the outer border of the foot. Paralysis of this last-named group of muscles produces in the course of time what may be termed a flat foot. This results from the disappearance of the arching of the foot.

In consequence of paralysis of the extensor adductor the foot naturally becomes abducted, the arch of the dorsal surface is increased, and instead of the flat foot above mentioned, we have a very decided hollowing out of the plantar side.

CHAPTER XIII.

ELECTRO-THERAPEUTICAL ANATOMY.

ELECTRO-THERAPEUTICAL anatomy includes a description of the localities at which the different nerves, muscles, and organs can be best affected by the electric currents, and also the relative electric sensitiveness of the different parts of the body. It is therefore to electro-therapeutics what surgical anatomy is to surgery.

The subject of the motor points was first systematically studied by Ziemssen, who experimented on the recently dead subject, and marked with nitrate of silver the points at which the individual nerves and muscles most readily responded to faradization. Many of these points can be easily and successfully studied on the living human subject. Those which are represented in the cuts are derived mostly from numerous observations on persons in health. They have been found to agree in the main with those of Ziemssen, with which they have been compared, and by which they have been made more accurate and complete. Those who wish to examine the subject in greater detail are referred to the work of Ziemssen.*

It will be found, however, that those which are here described are sufficient for most of the purposes of electro-therapeutics.

The best method of verifying these points is to place one large sponge electrode, well moistened, on some indifferent point, and to firmly press a small negative † electrode, also well moistened, over the spot where the nerve or muscle should be affected. If the right place is touched, and the strength of the current and the pressure be sufficient, the normal physiological action of the part affected will at once appear. In the case of muscles contraction will take place, accompanied with a feeling of contraction ; in the case of nerve-branches and plexuses, there will be sensation more or less painful along the peripheral ramifications of the nerves, and, if the excitation be sufficiently strong, contraction of the muscles which they supply.

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* Die Electricität in der Medicin. Berlin, 1866. p. 154, *et seq.*

† The negative is to be preferred, because it is the stronger, and acts more powerfully in producing contractions. (See p. 165.)

It is not to be understood that a studious regard for all of these electric points is always necessary in making applications of electricity. In the normal condition most of the superficial and many of the deeper muscles and nerves are easily excited by ordinary labile applications with large sponge electrodes. Some of the muscles have two or more motor points, and are therefore more readily affected by large than by small electrodes. (For remarks on the comparative pain caused by small and large electrodes, see p. 239.)

A large sponge electrode of from 3 to 6 or 8 inches in diameter, folded over a brass ball, such as is used in general electrization, causes full contraction of a majority of the superficial and deep muscles when rapidly passed up and down the limbs.

But when the muscles have become diseased, so that they respond with difficulty to the electric current, it becomes necessary to give special heed to the situation of these motor points, in order to determine their actual electric condition, or to aid in restoring them to their normal condition by exciting artificial contraction.

It should be remarked furthermore, that these electric points vary in different individuals, just as the anatomical relation of the nerves and muscles varies, and that the representations of the cuts can be only approximately correct.

The points at which the nerves and muscles of the eye, ear, and larynx can be best electrized, also the best method of electrizing the œsophagus, rectum, genital and abdominal organs, will be described in the chapters devoted to the diseases of those parts.

We present below a brief description of the points at which the principal nerves, plexuses, and branches can be best excited electrically, and also the physiological effect on the nerves and muscles produced by such excitation.

Facial—at its exit from the stylo-mastoid foramen, between the mastoid process and the angle of the lower jaw, or at the opening of the external auditory canal.

Pneumogastric—at the lower and anterior part of the neck, between the common carotid artery and the jugular vein; *inferior laryngeal*—between the œsophagus and the trachea of the ganglia of the sympathetic.

The *superior cervical* ganglion of the sympathetic can be reached in the anterior maxillary fossa, just behind and below the angle of the lower jaw; the *middle cervical*, by the side of the sterno-cleido mastoid muscle, opposite the fifth cervical vertebra; the *inferior cervical*, also by the inner border of the sterno-cleido mastoid muscle, opposite the second cervical and first dorsal vertebræ.

Accessory—at its exit from the sterno-cleido mastoid muscle.

Hypoglossus—between the stylohyoid and hyoglossus muscles, under the hyoid bone.

Phrenic—at the outer border of the sterno-cleido-mastoid muscle, by the anterior border of the scalenus anticus, near the omohyoid muscle. Excitation of this nerve causes strong movements of the chest.

Brachial plexus—in the supra-clavicular space, posterior to the outer border of the sterno-cleido mastoid muscle. Excitation of this plexus causes a feeling of tingling and numbness in the fingers and down the arm, and, when the current is strong, flexion of the forearm and fingers.

Dorsalis scapulæ—at the border of the trapezius, near the accessory.

Supra scapularis—just before its entrance into the scapula, and external to the omohyoid muscle.

Anterior thoracic—at the upper border of the pectoralis major, below the clavicle.

Posterior thoracic—above the clavicle, near the trapezius.

The thoracic nerves are irregular in their distribution, and therefore difficult to find.

Axillary—at the upper and posterior border of the axilla.

Musculo-cutaneous—between the biceps and coraco-brachialis.

Median—in the lower third of the arm, at the point where it crosses the brachial artery. Mild excitation of this nerve causes tingling in the arm and fingers; a strong excitation causes closure of the fingers and pronation of the hand.

Ulnar—at the groove between the olecranon and the internal condyle. Excitation of this nerve causes pain in the inner surface of the forearm and contraction of the flexor carpi ulnaris, flexor digitorum profundus, adductor pollicis lumbricalis, and interossei of the little finger.

Radial—in the lower third of the arm, at the point of its emergence from beneath the triceps. Excitation of this nerve causes tingling in the outer part of the arm and forearm, and down to the wrist; strong excitation produces extension of the first phalanges of the fingers, extension of the hand and thumb and supination of the forearm, contractions of the extensor carpi radialis and ulnaris, extensor digitorum communis, extensor minimi digiti, extensor indicis prop., extensor pollicis longus and brevis, adductor pollicis.

Ischiatic—in the thigh, posterior to the head of the femur, at the point where the nerves issue from the pelvis, or in the pelvis, through the posterior wall of the rectum. Electrization of this nerve causes sensations of tingling in the leg below the knee, and foot, similar to those which we so often experience when we accidentally sit on the sciatic nerve.

Crural—just after its exit from beneath Poupart's ligament, exterior to the crural artery. Electrization of this nerve causes sensations in those parts of the leg that are supplied by its branches.

Obturator—on the horizontal branch of the pubic bone. If the application is successful, and the current used sufficiently strong, the thigh is abducted.

Popliteal—in the outer part of the popliteal space. Electrization of this nerve causes vigorous contraction of the muscles that move the foot upward and outward.

Peroneal—on the posterior border of the capitulum fibular.

Excitation of this nerve causes contraction of the tibialis anticus, peronei muscles, extensor digitorum communis longus, extensor digitorum communis brevis, and extensor hallucis longus.

Tibial can be reached on the middle and outer part of the knee. When strongly electrized, contractions arise in the muscle of the posterior part of the leg.

The tibial nerve can also be reached in the depression posterior to the internal malleus.

Very many muscles have no accessible motor points, and must therefore be electrized intra-muscularly. Practically this is done in the majority of cases. We present in the accompanying cuts a bird's-eye view of the electric points of the prominent nerves, plexuses, and muscles, and of the relative sensitiveness of different parts of the surface of the body to the faradic current.

The relative sensitiveness of the different parts of the surface of the body to faradization, we have also ascertained by numerous comparative observations on persons in health, with the moistened hand and well-moistened sponge electrodes. The method of making these observations is to place the patient in the position for general electrization (see cut 48, p. 192), with his feet on the plate to which the negative pole is attached, while the experimenter applies the positive all over the surface of the body.

We have distinguished five degrees of sensitiveness, the highest being marked one. For all practical purposes these are sufficient; approximate accuracy is all that is attempted. The sensitiveness of the body when irritated by the faradic current is due partly to the quality and position of the sensory nerves, and partly to the peculiar feeling that attends muscular contraction (electro-muscular sensibility).

The feeling of muscular contraction amounts in some instances to actual pain, so that a part which is not richly supplied with sensory nerves may yet be very sensitive to the current. This is especially the case with the sterno-cleido-mastoid muscle, which on being touched near its centre contracts with a painful jerk. The same is true, to a less extent, of the trapezius, the flexors of the arm, and of the peronei muscles. In all parts where no muscular contractions are produced, the sensitiveness of the surface of the

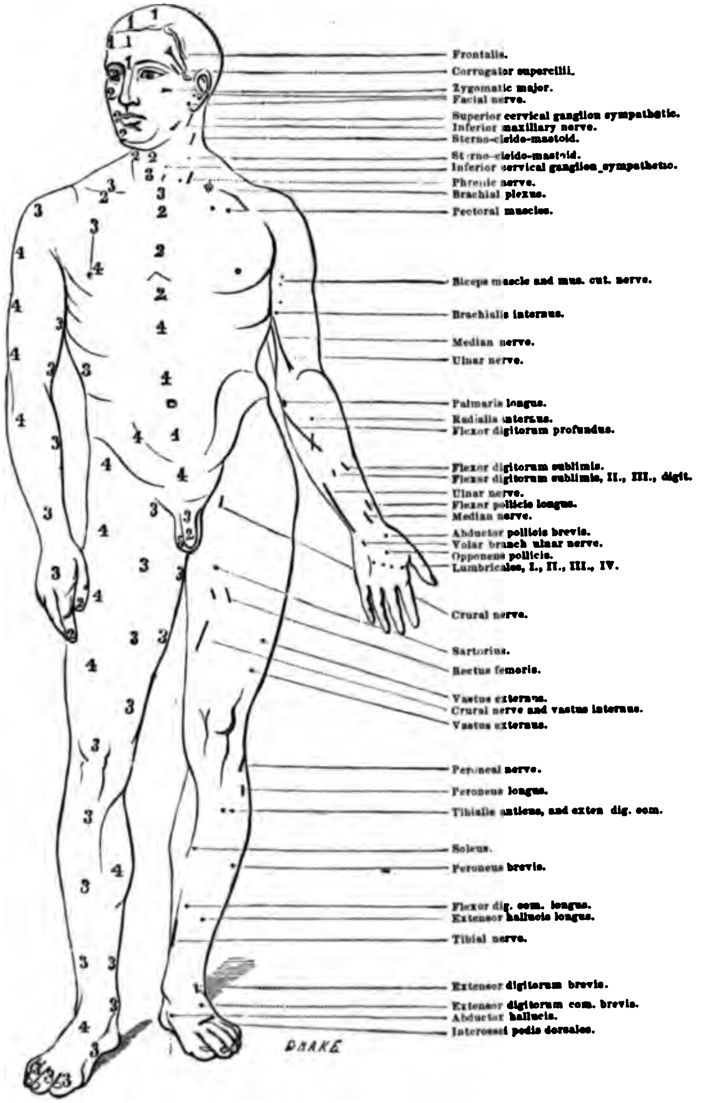
Frontalis.
Corrugator supercilii.
Zygomatic major.
Facial nerve.
Superior cervical ganglion sympathetic.
Inferior maxillary nerve.
Sterno-cleido-mastoid.
Sterno-cleido-mastoid.
Inferior cervical ganglion sympathetic.
Phrenic nerve.
Brachial plexus.
Pectoral muscles.
Biceps muscle and mus. cut. nerve.
Brachialis internus.
Median nerve.
Ulnar nerve.
Palmaris longus.
Radialis internus.
Flexor digitorum profundus.
Flexor digitorum sublimis.
Flexor digitorum sublimis, II., III., digit.
Ulnar nerve.
Flexor pollicis longus.
Median nerve.
Abductor pollicis brevis.
Volar branch ulnar nerve.
Opponens pollicis.
Lumbricales, I., II., III., IV.
Crural nerve.
Sartorius.
Rectus femoris.
Vastus externus.
Crural nerve and vastus internus.
Vastus externus.
Peroneal nerve.
Peroneus longus.
Tibialis anticus, and exten dig. com.
Soleus.
Peroneus brevis.
Flexor dig. com. longus.
Extensor hallucis longus.
Tibial nerve.
Extensor digitorum brevis.
Extensor digitorum com. brevis.
Abductor hallucis.
Interossei pedis dorsales.
DRAKE

FIG. 54. Electro-therapeutical Anatomy of the Human Body. Anterior view. (For explanations see letter-press.)

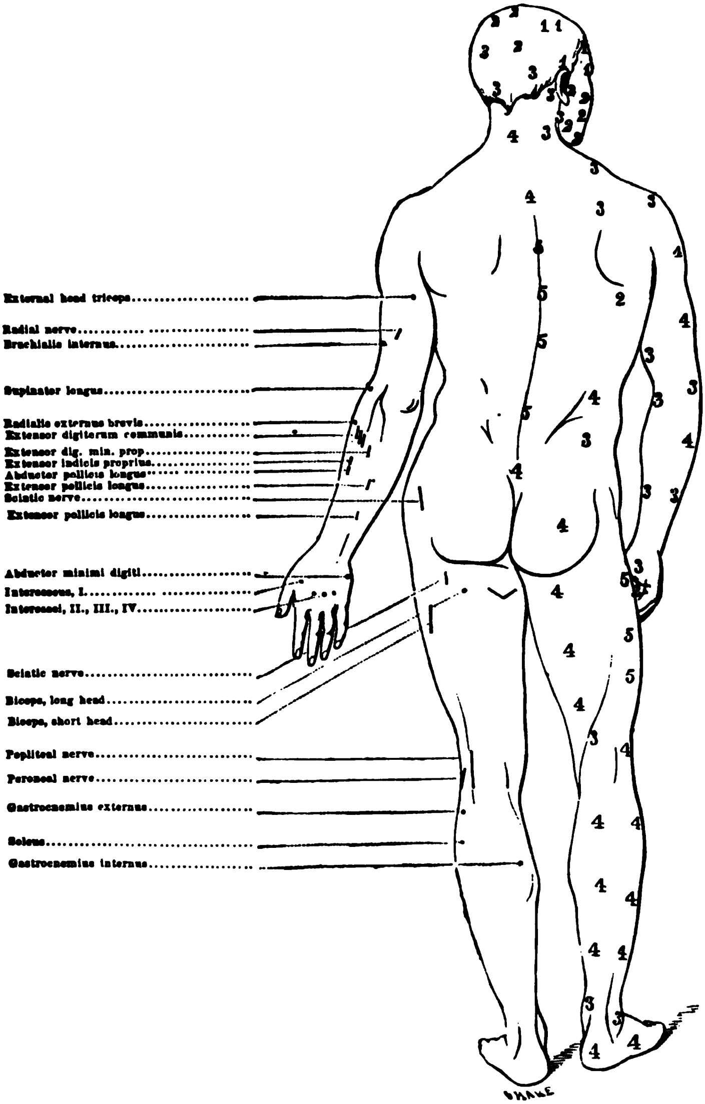

FIG. 55. Electro-therapeutical Anatomy of the Human Body. Posterior view. (For explanations see letter-press.)

body depends on the quality and position of the sensory nerves, and bears a pretty constant relation to its sensitiveness to ordinary mechanical irritation.

Thus it will be observed that the parts which are most sensitive to a blow or fall, or to any mechanical injury,—as the head, face, or surface of the bones, clavicle, sternum, scapula, patella, etc.,—are likewise marked highest in the scale of sensitiveness to the current.

To guard against error it is necessary—

1. To use always the same electrode and the same direction of the current; therefore the negative pole should be kept at the feet during the entire sitting.
2. To make the pressure of the electrodes uniform, and to moisten well all parts supplied with hair.
3. To use the moistened hand for the head and face. The head, especially, is so exceedingly sensitive to the faradic current that it will hardly bear a sufficient strength of current through a sponge to make a comparative estimate.

It will be observed that only a few parts are marked 5—the middle of the back, the outer surface of the thigh, and the testicles. The perinæum, which cannot be represented in the cut, should also be marked 5. It will be observed that the points most highly sensitive are those where very sensitive nerves pass over the surfaces of bones, as the head and jaws. Of the other parts not represented in the figures, the external auditory canal should be marked 1; the middle of the sterno-cleido-mastoid muscle, 2; the axilla, 3; and the ends of all the fingers, 2; the under side of the penis, 2; the point between the penis and scrotum, 4; the under surface of the heel, the plantar arch, the ball of the foot, 4. If the external auditory canal, drum of the ear, conjunctiva, nasal mucous membrane, tongue, and larynx were represented, they should be marked a degree or two higher than 1, since they are more sensitive than any portion of the surface of the head. The best point to test a current of extreme feebleness is the tip of the tongue.

The rectum, urethra, and vagina are but little sensitive to the current in comparison with the mucous membranes of the mouth, except at their external orifices. They might be marked 4 or 5. The os uteri and the bladder would be marked 4, 5.

It should be distinctly understood that these remarks apply to the applications of the faradic current with electrodes sufficiently moistened to allow the current to pass readily through the epidermis. In dry faradization the results are somewhat different, the pain at all parts being far less.

The galvanic current causes a burning sensation wherever it is applied; but this is most sensitively felt at those parts that are abundantly supplied by sensory nerves.

The greater sensitiveness of the bones to the faradic current, as compared with the galvanic current, is due to the greater mechanical action of the former. An interrupted galvanic current, of sufficient strength to produce muscular contractions, produces the same sensations as the faradic current, with the addition of the burning feeling at the surface beneath the electrodes. The fact that the galvanic current is less painful to the surfaces of the bones gives it a certain advantage in making applications to the head, although the pain of the faradic current, when applied to the head by the moistened hand, may be reduced to a minimum.

A knowledge of the relative sensitiveness of the different parts of the body to the electric current is indispensable both in *electro-diagnosis* and *electro-therapeutics*. It is at once obvious that to determine by the electric test the extent of anæsthesia, or loss of electro-muscular sensibility, in cases of paralysis, without a previous knowledge of the normal sensitiveness of the parts to the electric current and the normal feeling of electro-muscular sensibility in the affected muscles, is simply impossible. From a want of this knowledge very important mistakes are made in electro-diagnosis. In general faradization a knowledge of the relative sensitiveness of all the parts of the surface of the body enables one to make an application which would otherwise be painful, and perhaps injurious, both painless and refreshing.

CHAPTER XIV.

ELECTRO-DIAGNOSIS.

A HISTORY of the use of electrization as a means of diagnosis would very likely be the history of electro-therapeutics itself. As soon as men began to use the voltaic pile in the treatment of paralysis and kindred diseases, about the middle of the last century, just so soon, probably, they began to test the power of the electric current to diagnosticate disease. We logically infer that electrization was used as a means of diagnosis much earlier than the published treatises on the subject would show, from the fact that it has been so used—in a blind and empirical way, it is true—in this country, for thirty or forty years. Mankind, always and everywhere, are superstitious, credulous, ready to receive whatever approaches them with an air of mystery, much more so in the last century than in the present; and it is certainly not unfair to suppose that the earlier experimenters in this department consulted, to a greater or less extent, the diagnostic or prophetic power of the subtle agent—electricity. Their experiments, we may suppose, were unscientific and unsatisfactory. They were probably neither based on any well-defined principles, nor conducted by any intelligible system. Accordingly, they secured very few tangible, or at least communicable results, and if scientific men had not espoused the cause of electro-therapeutics, the phrase electrization, as a means of diagnosis, would never have been known. Nearly all that has been accomplished in a scientific way, in this department, is comparatively recent; though Marshall Hall earnestly called the professional attention to the fact that Electricity might assist us in differentially diagnosticating paralyris, as far back as 1839.* Since that time the subject has been ably studied by Todd, Duchenne, Remak, Benedikt, Meyer, and, to a greater or less extent, by nearly all the workers in the department of electro-therapeutics.

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* Medico-Chirurgical Transactions, 1839.

The foundation principles, on which Electrization can be made a means of diagnosis of disease, are simply these four:—

First. The fact that all the parts and organs of the body are more or less sensitive to the electric current, and that this sensitiveness is modified by disease.

If an electric current be passed through a boil, or irritable ulcer, or the skin, like any other irritant, it excites more pain than when it is applied over the healthy skin; and this pain which it causes usually bears quite a direct proportion to the nature and condition of the morbid process. This is so familiar and so apparent, that to state it is to demonstrate it.

Now, the electric currents, during the various processes of electrization, penetrate beneath the skin, and, as it has been experimentally and practically demonstrated, traverse, to a greater or less extent, the principal vital organs. It is evident, therefore, that those organs which are abnormally sensitive, through disease of any kind, must feel the current much more appreciably than when in a condition of health. But the mechanical effects of the electric currents work both ways, and organs which are indurated or changed into an anæsthetic condition by disease are less sensitive than is normal to the electric current, just as they are less sensitive to any other mechanical cause acting upon them.

Accordingly, we find that when even powerful electric currents are passed through an indurated joint, or an atrophied liver, they may produce no sensation whatever.

Before making examinations to determine the sensitiveness of the different parts of the surface of the body, it is necessary to know their relative normal sensitiveness, as indicated and described in the chapter on Electro-Therapeutical Anatomy.

It need hardly be said that the diagnosis obtained by this increased or diminished sensitiveness, of any part or organ must, of necessity, be a very general one. It simply informs us of, and directs our attention to, the fact, that such a part or organ is in some way diseased. The special nature of this disease must be determined by the ordinary means of differential diagnosis at our command. This sensitiveness to the electric current is particularly marked over the prominent nerve-tracts, and in those regions endowed with great tactile sensibility. If even a mild current be applied at those points on the upper or lower limbs where the prominent nerves are superficial, a feeling of tingling or numbness is felt through the branches of the affected nerve; and if the current is very much increased in strength, a decidedly anæsthetic effect is experienced. In paralysis of sensation, or anæsthesia, this feeling of tingling, thrill, and numbness, is very much diminished under the influence of the electric current, or is entirely absent. It is on this principle that electrization becomes a most valuable means of diagnosis in the various stages of anæsthesia. A condition of anæsthesia or analgesia (loss of sense of pain) can readily be detected by the brass ball employed in general electrization, or by the metallic brush, or by any other form of electrode. To detect analgesia the electrode should be moistened so that the current may penetrate the epidermis.

General electrization is found to be of great practical utility in aiding us both to determine the nature of certain diseases, and, in some cases, their precise locality. In dyspepsia, electrization often reveals great sensitiveness in the epigastric region, and on the left side over the spleen. In severe dyspepsia, accompanied by emaciation, a current is sometimes painfully trasmitted from the middle of the back to the stomach, through the solar plexus. A peculiar sinking sensation is sometimes felt at the pit of the stomach when a strong current is applied over the seventh cervical vertebra, or over the brachial plexus. All these symptoms, taken together, undoubtedly suggest an aggravated case of dyspepsia, and usually of the nervous variety. Congested or irritable states of the liver are revealed by an abnormal and peculiar sensitiveness when the current is applied over the right hypochondriac region. Care must be taken, however, not to confound the normal sensitiveness of the superficial nerves over the ribs, with an abnormal condition of the liver. There are certain diseases of this organ in which it is less sensitive than usual to electrization, and sometimes it appears to be decidedly anæsthetic.

A lady patient of ours who had suffered for years from hepatic disorder was very sensitive to the current excepting over the right hypochondriac region, where she could bear the whole power of the apparatus without any discomfort, except that which was necessarily caused by the natural tenderness of the skin. The precise condition of the liver at that time we were not able to ascertain. The evidence, however, was sufficient to confirm our previous suspicions in regard to the existence of some affection of that organ. It may be said in general, that those diseases which cause the liver to be sensitive to external pressure, also cause it to be sensitive to electrization. The same general principle will apply to the stomach, the spleen, the intestines, and the ovaries. Our experience in the electrical treatment of diseases of the lungs has not been large, but it has been sufficient to make it quite probable that certain sensitive conditions of tuberculous deposit may be suggested by abnormal sensitiveness over the apex of the chest.

In making an electrical examination of the chest, care should be taken to avoid the ribs, since the nerves of their periosteum are remarkably sensitive to the faradic current.

Electro-diagnosis of the sensitory nerves requires us to examine the condition not only of the various portions of the skin, but also of the nerve-branches, the plexuses, and the posterior nerve-roots.

If in cutaneous anæsthesia we find normal sensitiveness on the nerve branches, we judge that the disease is confined to the alternate nerve ramification only.

If in complete anæsthesia of an extremity the nerve plexus exhibits a normal reaction, we also judge that the disease is not central but peripheral, including the nerve-branches.

For the purpose of testing the condition of sensation, the faradic current is usually to be preferred, for the reason that its mechanical effects are greater than those of the galvanic.

The Brain.—In health the head is very sensitive both to galvanization and faradization, in all parts except the posterior. In pathological cases this sensitiveness may be either increased or diminished. The sensitiveness of the head is probably due more to the reflex action of the superficial nerves, and especially of the fifth pair, than to the direct sensations of the brain itself.* In physiological cases the symptom of dizziness follows galvanization of the brain, if the sitting be at all protracted; in pathological cases this symptom may be greatly exaggerated, or, on the other hand, may be manifested only from a very strong current.

Spinal Cord.—In health the spinal cord is but little sensitive to the current. In pathological cases it may exhibit a sensitiveness to the electric current that is not revealed by pressure or by any other method of irritation. This condition is found in neuralgia, spinal irritation, hysteria, etc. It is interesting, also, to know that electric examination sometimes indicates abnormities in the sensitiveness of certain parts of the body that exhibit no functional derangement.† (For proofs that the brain and spinal cord are directly affected by external electrization, see p. 86 et seq.)

Sympathetic.—The ganglia of the cervical sympathetic may be examined electrically by the inner border of the sterno-cleido-mastoid muscle. Sometimes all three of the ganglia are abnormally sensitive to galvanization. This sensitiveness is found in a large number of pathological conditions, locomotor ataxy, muscular atrophy, various cerebral affections, etc. We have observed it also in spinal irritation, and during paroxysms of sick headache. This abnormal sensitiveness may be frequently demonstrated by mechanical pressure.

Electro-muscular sensibility includes, as Benedikt‡ remarks, a *feeling of pain and a feeling of contraction.* The latter may exist without the former.

Success in investigating electro-muscular sensibility depends on the condition and intelligence of the patient.

In conditions of cutaneous hyperæsthesia it is exceedingly difficult, even for the most intelligent patient, to distinguish between the sensitiveness of the skin and that of the muscle.

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* The remarkable case of anæsthesia reported by Althaus (op. cit., p. 137 et seq.), would seem to show that the sensations experienced by electrization of the head are largely due to reflex action through the fifth pair.

† Benedikt, op. cit., p. 60.

‡ Op. cit., p. 62.

In paralysis electro-muscular sensibility is frequently diminished, together with the electro-muscular contractility; they often rise and fall together. In hysteria, electro-muscular sensitiveness to pain is sometimes greatly increased. Sensation of pain must not be confounded with the feeling of contraction when a muscle responds to the electric current. The sensation of pain may be produced by the prick of a needle, or by the passage of an electric current that is too feeble to cause contraction of the muscles. The subjective feeling of *numbness*, of which patients so frequently complain, and that accompanies anæsthesia, may exist with it, or at least may exist in those cases where the æsthesiometer detects no diminution of sensibility.

Second. The fact that the electro-muscular contractility and irritability are more or less modified by disease.

Irritability strictly refers to the quivering which muscles exhibit under mild currents; contractility to the power of actually contracting under whatever strength of current may be necessary. The two terms are very frequently used interchangeably.

That muscular contractions can be produced by the electric currents, has been known since the period of the earliest investigations in the department of electro-physiology.

The first systematic attempts to make this a basis for establishing differential diagnosis were made by Dr. Marshall Hall, and subsequently by Dr. Todd. The conclusions of these distinguished experimenters are quite familiar, and as they were unsatisfactory and partly erroneous, it is not necessary to present them in detail. More recent investigations have established that the behavior of the deep-seated muscles, in regard to their contractility, is a much more complicated question than was formerly supposed. The contractile power of a muscle is made up of two factors, viz.: the excitability of the intra-muscular nerve fibres, and the functional capacity or irritability of the muscular substance itself.

When, therefore, the contractile power of a muscle differs in any respect from the normal, this variation may be due to an abnormal condition of either one or both of these factors. Still further, it is known that when the excitability of the intra-muscular nerve fibres and the irritability of the muscular substance are increased, yet if the former has suffered more than the latter, the contractile power may be diminished, and *vice versâ.* (Benedikt.) *In comparing healthy with diseased sides in paralysis, it is necessary to use not only the same strength of current, but also the same direction of the current, and the same relative position of and pressure on the electrodes.*

The general principles that have thus far been established, in regard to the relation of electro-muscular contractility to disease, are as follows :—

1st. In paralysis of motion, the electro-muscular contractility is sometimes normal, occasionally increased, and very frequently diminished.

Increase of electro-muscular contractility may be observed in diseases of the brain, attended with irritative lesion, in certain spasmodic and hysterical affections, and occasionally in locomotor ataxy. *Diminution* of electro-muscular contractility is usually observed in severe diseases of the spinal cord, in rheumatic paralysis, lead-palsy, in well-marked progressive muscular atrophy, and in paralysis from injury of a nerve in some part of its course.

2d. In certain central diseases, the electro-muscular contractility is at first normal or diminished, and afterwards increases with the progress of the disease, until it becomes greater than normal.

The length of time that is necessary to illustrate these variations depends on the nature of the disease. In chronic inflammations of the spinal cord, in effusions in the brain, causing hemiplegia, these variations may run through many weeks and months. In cases of hemiplegia also, these different conditions of the electro-muscular contractility may run in a circle; being sometimes normal, sometimes increased, and sometimes diminished. (Benedikt.) All these changes correspond, of course, to certain changes in the pathological condition of the diseased brain. Just what this correspondence is in each case, cannot, in the present state of electro-pathological science, be well determined.

In cancer of the brain and similar extending affections, there may be a remission of the muscular contractions during electrization.

According to Benedikt, this is an evidence of pathological exhaustion. This has been observed in aphasia.

3d. The fact that certain forms of paralysis behave very differently under the faradic and the galvanic current. Muscles over which a faradic current can have no influence, may contract easily under a milder galvanic current than is necessary to produce contractions of the same muscles in health. Sometimes, as the paralyzed muscles recover, they regain their power of contracting under the faradic current, at the same time proportionately losing their contractility under the galvanic.

This fact, that in certain peripheral paralyses *galvano-muscular contractility may remain after farado-muscular contractility is wholly lost,* was first pointed out by Baierlacher in 1859. His observations have since been confirmed by Schulz, Meyer,[*] Hammond, Radcliffe, Ziemssen,[†] Legros and Onimus,[‡] ourselves,[§] and other observers. (See section on peripheral paralysis.)

From the experiments of Neumann and Brückner, it would appear that this difference in the action of the two currents is due to the longer duration of the galvanic current, which allows it to produce an effect on the diseased muscles which the faradic current, on account of the rapidity of its interruption, could not produce.

It was found by these observers that, in cases of muscular degeneration, where contractions under the galvanic current were more readily excited than in the corresponding muscles of the healthy side, no effect was produced *if the current was very rapidly interrupted.* The same phenomena were obtained from experiments on the sciatic, crural, tibial, and peroneal nerves. It has been suggested by Eulenburg that just as the sensory nerves have several distinct functions, as touch, sensibility to pain, temperature, pressure,—one or more of which may be abolished while the rest are intact,—so the motor nerves may have three distinct powers, —response to galvanization, to faradization, and to the will,—one or two of which may be separately injured or abolished by disease.

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[*] Op. cit., p. 417.

[†] Electricität in der Medicin, 1866, p. 76.

[‡] Op. cit., p. 61.

[§] New York Medical Record, 1868, p. 409.

In regard to their irritability when in a pathological condition, muscles and nerves are subject to different laws.

It has been shown by Erb,* and corroborated by Ziemssen and Weiss,† that the motor nerves, when they have been so injured as to lose their irritability to the faradic current, also lose their irritability to the galvanic current, and that the increased irritability which is seen in such cases under galvanization is due to the *muscles.*

After the nerve has been injured by actual division, by bruising, or by rheumatic effusion, it at once begins to lose its irritability to both galvanic and faradic currents.

This diminution of irritability advances from the centre towards the periphery, and at the end of the second week both galvanic and faradic irritability are destroyed. As the nerve recovers, irritability to the galvanic and the faradic currents reappear together.

With the muscles, on the other hand, there is at first no lessening of the irritability to either current until after a week. At this time the faradic irritability begins to fall and the galvanic irritability begins to rise.

In a few days the galvanic irritability becomes so much increased that the muscles respond to a much feebler current than usual.

At this stage there is a change in the character as well as in the degree of the irritability of the muscles.

This change is twofold :—

1. The negative pole produces as great or greater effect on opening than the positive : in a normal condition of the muscles the positive produces greater effects on opening than the negative.

2. The positive pole produces a greater effect on closing than on opening; in a normal condition of the muscles the greater effect at the closing is produced by the negative pole.

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* Deutsches Archiv für klinische Medicin, Band iv., 1866.

† Ibid., Band iv., 1868.

In about twelve weeks there is a renewed diminution of galvanic irritability; this diminution goes on until twice as great a strength of current is necessary to produce contractions as in the corresponding muscles of the healthy side. Slight contractions may now be produced by the faradic current.

These changes of irritability seem to bear no definite relation to the volitional power.

It should be remembered that the characteristic reaction of paralyzed muscles to the electric influence is frequently not observable at the outset of the disease: sometimes several weeks elapse before there appears the diagnostic evidence of changed electro-muscular contractility or sensibility. Especially is this the case in spinal paralysis, also in rheumatic and facial paralyses, sometimes also in hemiplegia. Again, it is necessary, in doubtful cases, not to depend on any single examination, but to form an opinion from a number of examinations taken at different times.

If a muscle exhibits diminution of contractility under electric irritation, but reacts normally to the *will*, the conclusion is that the muscle is not injured, but that the abnormity is caused by change in the irritability of the intra-muscular fibres. This is observed in certain stages of traumatic and lead paralysis.

We arrive at the same conclusion in those cases where the muscles refuse to contract under direct, but respond normally to indirect, electrization.

Muscles of the eye are an exception to this rule, since, from their anatomical position, they cannot be made to contract by direct, but only by indirect, reflex action from the fifth pair.

Cases where reaction is lost both to the will and electrization indicate actual injury of the muscle.

Furthermore, it should be considered that the electro-muscular contractility and sensibility of diseased muscles may be and are greatly modified by the treatment, both permanently or temporarily. Thus galvanization of the sympathetic in muscular atrophy increases, while galvanization of the brain in hemiplegia sometimes diminishes, the electro-muscular contractility of the affected muscles. Modification may take place even during the séance. Another fact of interest and importance is that electric examination sometimes reveals changes in ***muscles that manifest no functional disturbance.***

Third. That the ***physiological reaction of the central and peripheral nervous systems to the galvanic current is essentially changed when the nerve is in a pathological condition.***

This is true of the spinal cord, the motor and sensitive nerves, of the nerves of special sense, and of the sympathetic. According to Benedikt, if the negative pole is placed, for example, on the peroneal nerve, and the positive on the patella, with an interrupted current, a weaker irritation appears than when the positive pole is placed on the cervical or lumbar vertebræ. The more the central parts are included in the circuit the greater the irritation. In pathological conditions this reaction is changed.

On the subject of altered irritability of nerve-tracts Benedikt thus remarks :—*

1. That the motor irritability of the ascending current in the normal condition, in the nerve-muscle, plexus-nerve, and plexus-muscle current, is greater than the descending, and that this relation is changed in pathological cases.

2. That the motor irritability increases from the periphery toward the centre when the poles are so placed as to include more central portions of the nerve-tract in the circuit.

3. *Opening contractions* are regarded by Benedikt as characteristic evidences of certain forms of locomotor ataxy. They are observed also in neuritis and in *chorea minor.* They indicate a molecular disturbance. They accompany both increased and diminished irritability, usually the latter.†

Auditory Nerve.—Brenner and Erb have shown that the reaction of the auditory nerve to galvanic irritation—the strong subjective sensations of sound—is materially changed by disease ; and by this they judge of the condition of the nerve. (See Diseases of the Ear.)

Optic Nerve.—The reaction of the optic nerve under the influence of the galvanic current reflected from the fifth pair, or from other nerves in the neck, is attended with flashes of light. In certain pathological cases, as we have observed, flashes of light may be produced by the faradic current. In other pathological cases the flashes of light do not appear during galvanization, or only when a very strong current is used. We have observed very marked differences in the reaction of the optic nerve in the two eyes when one was diseased and the other healthy. Flashes of light from galvanization of the lower part of the spine are indicative of abnormal irritability or organic disease of the spinal cord. They are observed in locomotor ataxy and spinal irritation.

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* Op. cit., p. 56.

† These views of Benedikt, concerning the significance of "opening contractions," have been severely criticised by Brenner ("Untersuchungen," &c., Bd. II., 1869, p. 215 et seq.).

Olfactory and Gustatory Nerves.—The peculiar smell that is experienced on galvanization of the olfactory nerve may be either increased or diminished by disease. It is absent in paralysis of the olfactory nerve.

The peculiar metallic taste that follows galvanization of the tongue, or that is experienced by reflex action when the galvanic current is applied on the neck and upper part of the spine, is subject to various modifications by disease. In irritable conditions of the cord we have observed that this metallic taste will appear when the application is made in the lower part of the spine. In two striking instances it was experienced from faradization of the *cilio-spinal* region.

Fourth. *The fact that in certain central diseases, and in conditions of exalted irritability, as hysteria, the effect of the electric current in the periphery is sensitively transmitted to the cord, and by reflex action may be communicated to the other half of the body and to the entire periphery, so as to produce contraction.*

This phenomenon never occurs in health. We have usually observed it in organic diseases of the central nervous system. It is entirely probable, however, that it might occur in severe exhaustion of the cord attended with hyperæsthesia; but from our present experience we regard this symptom—viz., the sensitive reflex action of the electric current—as frequently indicative of inflammation, or at least congestion, of the cord or of its membranes. The first case in which we observed this remarkable phenomenon was that of a lady of middle life, who, for several years, had suffered from all the symptoms of declared chronic myelitis. We were first struck by the fact that even a very mild current over the upper portion of the back was sensitively felt down the right leg.

This symptom we have never known to occur in a perfectly healthy condition of the spinal cord. Afterward we found that a very short as well as very mild application of the current to one leg caused a disagreeable feeling of pain and heaviness not only in this leg, but also in the other, for several days following the application. In another case of general paralysis dependent on spinal congestion, a very feeble current localized in one hand, or in one foot, would be appreciably, and oftentimes painfully, felt through all the four extremities. The patient declared that the sensation was like that of " waves rolling through the body."

A still more marked illustration of the diagnostic power of electrization was the following:

In the case of a lady whose lower limbs had been somewhat paralyzed for two years, who presented thus far no marked symptoms of severe organic disease of the cord, we were inclined to suspect that her paraplegia might be due to nervous exhaustion, until this abnormal reflex sensitiveness to the electric current seemed to establish the existence of myelitis, or at least meningitis. We first observed that a feeble current in the neck was felt down the spine, and subsequently the patient complained that a strong current down the lower extremities transmitted pain to the back. The occurrence of this abnormal symptom forced us to the unwilling conclusion that we were dealing with a case of organic disease of the spine. The subsequent history of the case has confirmed this diagnosis. It has been shown by Benedikt,* that, in certain morbid conditions, electrization of one extremity produces contractions in the other. This phenomenon has been observed in progressive muscular atrophy, and in certain reflex neuroses.

This fact enables us not only to make a diagnosis of central disease, but in certain cases even to localize the precise seat of the affection. In a case of facial paralysis, in which electrization of the affected side produced a throwing backward of the trunk, Benedikt* ventured the diagnosis of infiltration at the origin of the trigeminus, which was confirmed on a post-mortem examination by Dr. Meyeet.

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* Die Elektrotherapie, p. 63.

We are confident that in all these cases of crossed reflex contractions—just as in the cases of crossed reflex sensation above cited—there is always some central disease. This symptom when it occurs may then be regarded as diagnostic.

Crossed reflex sensations and crossed reflex contractions may be manifested simultaneously in a patient affected with organic disease of the spinal cord. This singular coincidence was observed in the case above recorded of the lady who complained of waves of sensation all over the body when the current was applied to any one of the four extremities. These peculiar sensations were sometimes accompanied by feeble and spasmodic muscular contractions. Benedikt † states emphatically that crossed reflexes are diagnostic of affections of the pons varoli.

General shaking and tremor of a limb, or of the whole body, after electrization, is also diagnostic of central disease. We have observed it in one case of softening of the brain, and in a number of cases of hemiplegia. This general or partial tremor does not appear unless a considerable strength of current has been employed, or the application has been much prolonged.

Under this head are properly included the "diplegic contractions" described by Remak, Fieber,‡ and Benedikt.§ (See Chapter on Sympathetic.

Feigned Diseases.—By the application of the principles stated above, the electric currents may be of great service in helping us to distinguish real from feigned disease. A case of pretended paralysis of motion or sensation can readily be settled by applying the current to the limb, since no force of will can fully resist the energy of the contractions that electricity may excite in healthy muscles, or the pain that can be produced by strong faradization of the skin. The principle will work both ways, and, if the electro-muscular contractility is diminished below the normal standard, we may know that the disease is real. Where one side or one limb only is affected, the comparison between the healthy portions and those where disease is suspected can easily be made. Dr. Russell Reynolds* mentions a patient with hemiplegia who was supposed to be malingering. Electrization of the limbs on both sides showed clearly a diminution of contractility on one side, as the patient represented, and accordingly the case was pronounced to be one of real hemiplegia.

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* Op. cit., p. 64. † Ib. p. 65.

‡ Die diplegischen Contractionen nach Versuchen an Menschen und Thieren. Berlin, 1866.

§ Op. cit.,; p. 68, etc.

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* Lancet, April 16, 1870.

CHAPTER XV.

GALVANIZATION OF THE SYMPATHETIC.

THE attention of the profession was called to the therapeutical action of the galvanic current on the cervical ganglia of the sympathetic by Professor Remak,* of Berlin, who was the first to note the fact, now well recognized among electro-therapeutists, that contractions of the muscles of one or both of the upper extremities may be produced by placing the positive pole in the auriculo-maxillary fossa, just anterior to the ascending ramus of the lower jaw, and the negative by the side of the sixth cervical vertebra. The theory of Remak, that these contractions, to which he gave the name of "*diplegic*," were caused by irritation of the superior ganglia of the sympathetic, was confirmed by Fieber,† by experiments on animals in whom the sympathetic was exposed, and subjected to the action of the electric current.

Strong currents—from twenty to forty elements—are usually, though not always, necessary to produce these contractions. The contractions may be of various degrees, from mild drawing, with scarcely perceptible oscillations, to violent movements resembling chorea. They may appear in the interossei or in the muscles of the arm or forearm of one or both sides. They may also appear in other positions of the electrode than the one described. From one to five minutes are usually necessary to excite them, and they may continue for a few moments after the application has ceased.

There are two obvious reasons why galvanization of the sympathetic in the living man should not have the same marked effect as on animals when the ganglia are exposed.

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* Application du courant constant au traitement des neuroses. Paris, 1865.

† Die diplegischen Contractionen nach Versuchen an Menschen und Thieren. Berlin, 1866, pp. 21, 22, 23.

First. The anatomical position of even the most accessible ganglia is such that the current can only be applied to them by first traversing other tissues. It is therefore impossible for them to feel the full power of either pole.

Secondly. The sympathetic cannot be electrized without at the same time electrizing other important parts of the central or peripheral nervous system. Thus, in the first method (see fig. 40, p. 175), the upper portion of the spinal cord, and in the second method, the pneumogastric, is included in the circuit. In all the other methods either the brain or spinal cord must be more or less affected.

But although exclusive localization of the current in any of the sympathetic ganglia of the living man is impossible, yet the important physiological and therapeutical results that arise from applying the current, especially the galvanic, through those parts in which the ganglia are most accessible, show conclusively and in a most interesting manner that these ganglia are directly affected, and that the difference in the effects of such applications on the living and on the exposed animal are merely differences of degree.

In order to determine the physiological effects of galvanization of the cervical sympathetic, we have experimented considerably on ourselves and others in comparative health. The applications were made in the manner above described in figure 40, usually with a modification of Stöhrer's battery, or with a number of Smee's elements. The number of cells used ranged between ten and twenty-five, and the length of the séances was from two to five minutes. The effects experienced from these applications were as follows:—

1. *A slight feeling of drowsiness.*—This sometimes began to be perceptible shortly after the electrodes were applied, increased up to a certain point, and continued for some little time after the séance was over. In many cases it is not observed until the lapse of five or ten minutes after the séance. The feeling, which was by no means constant, was usually so slight that it might not have been observed, had we not in our experiments kept closely on the watch for every sensation experienced during or just after the application.

On the accepted theory that a state of cerebral anæmia predisposes to sleep, we should reason, *à priori*, that electrization of the sympathetic ought to induce a feeling of drowsiness, since it unquestionably diminishes the current of blood in the brain, and experimentally we have found that it does thus induce a slight and temporary disposition to sleep, although this result is probably far less marked than it would be if, without injury to the living subject, the application could be made directly to the ganglia.

Dr. Hammond [*] has found that galvanization of the sympahetic caused contraction of the vessels of the brain, as may be demonstrated by examining the retina with the ophthalmoscope during the application.

From observations that we have made at different times and by various methods of application, it would appear that anæmia of the retina is not a uniform or necessarily an immediate result of galvanization of the sympathetic, but that hyperæmia may sometimes be temporarily produced; and in other cases no change in the vascular condition of the retina is observed, beyond a slight enlargement of the veins.

In order to determine this question, we have instituted a number of experiments on our own persons, with the aid of several ophthalmologists.

The positive electrode, connected with a galvanic current of twenty Stöhrer's cells, was placed in the right auriculo-maxillary fossa, and the negative over the sixth and seventh cervical vertebræ. Dr. St. John Roosa examined the retina with the ophthalmoscope just before, during, and about five minutes succeeding the applications. During the passing of the current, Dr. Roosa observed that the arteries of the retina *increased* in size, and that more vessels were brought into view. The applications were continued from two to five minutes. On examining the condition of the retina, about five minutes after the application had ceased, Dr. Roosa observed a marked *decrease* in the size and the number of the arteries. It was evident that the secondary effect of the galvanization was to produce anæmia of the retina, since it presented fewer and smaller blood-vessels than before the application. The experiment was repeated on both of us, and on both sides, and with substantially the same results.

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[*] Journal of Psychological Medicine, April, 1870, p. 249.

Dr. Roosa subsequently repeated his examinations at the Manhattan Eye and Ear Infirmary, when a galvanic battery of smaller Smee's elements was used, and the negative pole was placed in the auriculo-maxillary fossa. He observed the same changes in the condition of the retina, though they were not fully as marked as in the preceding experiments.

Dr. Loring, who examined the retina with the ophthalmoscope before, during, and after the passing of the current, observed a marked increase in the size of the veins, but no change in the size of the arteries.

The same examination of the retina was afterwards made by Dr. Hackley, at our office. A feebler current was used than in the former experiments. He noticed a slighter enlargement of the veins, and also a slighter change in the arteries, but no decided anæmia after the application.

When the positive electrode was placed in the auriculo-maxillary fossa and the negative on the deltoid muscle of the opposite side, Dr. Hackley observed a very slight contraction of the arteries without any primary hyperæmia.

We had supposed that the enlargement of the veins observed by Drs. Loring and Hackley might be due to simple pressure of the electrode on the jugular vein, but Dr. Hackley failed to discover any change in the appearance of the veins, while very firm pressure was made on the auriculo-maxillary fossa by an electrode not connected with the battery.

In order to determine whether the *faradic* current could produce any effect on the vascular condition of the retina, we directed as strong a faradic current as could be borne through the cervical ganglia, in the manner described in Fig. 40 (p. 175). Dr. Hackley examined the retina before, during, and after application. At first no change was observed. After the séance had been continued twice as long as is usual when the galvanic current was employed, slight congestion of the retina was observable, which soon disappeared after the close of the application.

This observation, taken in connection with the clinical fact that general faradization is followed by the disposition to sleep and equalization of the circulation, as well as by changes in the pulse that are observed from galvanization of the sympathetic, shows pretty conclusively that the practical difference between the two currents is mainly one of *degree.*

Our observations would seem to show that the effects of galvanization of the cervical sympathetic on the retina, like the therapeutical effects, vary more or less with the strength of the current, the length of the application, and the position of the electrodes.

The subject is worthy of diligent and systematic investigation.

If it shall be established by further experiments that anæmia of the retina follows galvanization of the cervical sympathetic, and if it be conceded that the vascular condition of the retina uniformly partakes of the vascular condition of the brain (a question that is not yet fully settled), then the slight tendency to sleep, sometimes observed after this method of treatment, is satisfactorily explained. Since absolute and exclusive localization of the current in the sympathetic is impossible, the effects observed by ourselves are also not unlikely modified by the effect of the current on the upper portion of the spinal cord.

The same remark will apply to the therapeutical effects of these applications.

2. *A feeling of warmth through the system.*—This was not a constant symptom, though it was oftentimes very decided. A strong current may cause sensible perspiration. The extent to which this was felt was manifestly dependent on the strength of the current and the length of the application. It was usually felt but a short time after the séance was completed. We have observed this effect more frequently and more markedly in the susceptible and nervous than in the cold and phlegmatic, and most frequently in pathological cases.

3. *A marked effect on the pulse.*—It was sometimes accelerated, but more frequently lowered, two, three, four or more beats.

In order to determine the effects of electrization of the sympathetic on the pulse, we made the examinations immediately before and immediately after the applications. Every precaution was taken to avoid error, by allowing an interval of rest before the sitting, in order to give time for the subsidence of the pulse to its natural condition, from any excitement that it may have received from the exertion of walking or the labor of partially disrobing. In cases of doubt the whole minute was counted, in some instances several times in succession. A patient unaccustomed to the sensation produced by the electric current, or to the modus operandi of its employment, might experience an acceleration of the pulse from simple mental excitement, not only prior to or at the commencement of the sitting, but also during or after the application. Error from this cause was in our cases manifestly impossible, and all the others on whom we experimented with a view to obtain physiological results were so well familiarized to the medical employment of electricity that they would receive any treatment proposed with cool indifference. In order still further to guard against error, and at the same time to observe the continuance or permanency of the effect of the experiments, we repeated, in some instances, our examinations of the pulse at intervals of fifteen minutes or half an hour after the sitting was over.

A corroborative evidence that these changes in the pulse were due to the action of the current, and not to mental excitement, is found in the fact that, after an interval of five, ten, or fifteen minutes, the pulse returned to its original condition.

These changes in the time of the pulse were also accompanied by perceptible changes in its character, which, if careful sphygmographic observations had been made, might perhaps have been reduced to some general law.

Eulenburg and Schmidt (quoted by Althaus) found that when the positive pole of from 20 to 40 of Daniells' elements was placed at the *manubrium sterni* and the negative pole in the auriculomaxillary fossa, the pupil of that side was at first slightly dilated and afterwards contracted. These changes in the pupil are not uniform in their appearance. In some cases they appear at once after closing the circuit, and in others after the lapse of half a minute or minute, and in others still, after interruptions. These phenomena are liable to many variations, according to the strength, length, and locality of the applications. If an electrode is placed in the auriculo-maxillary fossa of each side, the changes in the pupil occur on both sides, but are more marked on the side on which is the negative pole. The same application, continued for some time with a strong current, reduced the normal pulse from 4 to 16 beats a minute, and the pathological pulse even more, diminished the tension in the carotid and vertebral arteries, and markedly altered their sphygmographic tracings. The same observers found that galvanization of the spine also diminished the beats of the pulse.

PATHOLOGICAL CASES.

Paralysis of the inter-ossei of the left hand—Diplegic contractions on galvanization of the sympathetic—Some improvement.

CASE 1.—Mr. P., afflicted with paralysis of the extensor muscles of all the fingers of the right hand, was directed to us by Dr. J. J. Crane.

The patient had observed some slight loss of power in the affected members for more than a year previous, but was unable to ascribe any cause other than a violent wrench to the hand, that was followed by several bursæ. A dozen applications of the galvanic current resulted in some very slight improvement in the condition of the paralyzed muscles. The so-called diplegic contractions in the diseased muscles were readily observed on galvanization of the cervical sympathetic. At first these contractions were induced only when a current of considerable intensity was used, but at each subsequent application less tension was required, until an exceedingly weak current was sufficient to produce the phenomenon. The patient somewhat improved under treatment.

Attacks of nausea and vomiting—Recovery under galvanization of the sympathetic, after failure of general faradization.

CASE 2.—Mr. S., aged 40, had complained of frequent attacks of nausea, that occasionally were accompanied by vomiting. The patient was of slight build, and of a thoroughly nervous organization. There were no evidences of organic disease either in the history of the case or in the special character of the symptoms. The attacks came on usually in business hours, and could not unfrequently be referred to mental anxiety. A strong evidence that the disease was mainly functional in its character was that on Sabbath days, when the patient did not go to the office, and was free from business cares, he was also free from the attacks.

Ordinary treatment, both by medication and by electricity, carefully and perseveringly employed by the usual methods, had failed to give substantial relief. As a last resort, we resolved to experiment with applications localized in the cervical sympathetic. The results were immediate and favorable; from the first application he began to improve, and in three weeks he regarded himself as cured.

This experiment was eminently a fair one, since it was tried alone, unaided and unimpeded by other remedies, immediately after other treatment, even that by electrization, had failed.

Myelitis—Tenderness over the superior cervical ganglion, and unusual sensitiveness to the faradic current—Disappearance of sensitiveness under general faradization.

CASE 3.—A lady of sixty years of age had suffered for three years with paraplegia, resulting from myelitis; was found to be extremely sensitive even to the faradic current when applied over the superior cervical ganglion. This sensitiveness was transmitted to the side of the sixth cervical vertebra, even though the other pole (which is usually applied to this place) was at some distant and indifferent point. This sensitiveness amounted to absolute pain when a current even of moderate strength was employed, and would probably have been still more marked under the influence of galvanization. This phenomenon, which we have never before observed in any case either of health or of disease, is probably to be explained by a peculiar and abnormal sensitive condition of the sympathetic. This probability is enforced by the results of the treatment and the subsequent history of the case: in the course of three applications this peculiar manifestation of sensitiveness entirely disappeared, so that it could not be evoked even under the influence of a current of considerable strength. At the same time the patient rapidly improved, both in her ability to walk and in her general condition, under the combined influence of central and peripheral applications.

The interesting point in the case is, that with the manifestation of improvement there was a diminution, and finally a disappearance, of the peculiar sensitiveness of the sympathetic. That in many and diverse cases of disease the cervical sympathetic may be positively and even painfully sensitive to pressure on the application of the electric current, and that this sensitiveness may disappear with the improvement of the patient, we have observed in a number of instances. Benedikt* has observed tenderness in the region of the cervical sympathetic in a variety of morbid conditions.

In that very frequent and obstinate malady, "sick-headache," for example, we have observed in a number of instances that on the affected side the cervical sympathetic is markedly sensitive to pressure, and that this sensitiveness persists during the attack and disappears with the subsidence of the pain. This phenomenon, which, we believe, has not before been pointed out, can sometimes be readily verified by making firm pressure in the direction of the superior cervical ganglion during the height of an attack of hemicrania.

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* See Elektrotherapie, passim.

Hemiplegia—Relief of injection of conjunctiva, by galvanization of sympathetic.

CASE 4.—The efficacy of galvanization of the cervical sympathetic, in reducing injection of the conjunctiva, was well illustrated in the case of a gentleman of 60 years, who was suffering from hemiplegia of the left side. He was attacked six months before we saw him, and for three months subsequently had been able to walk only with difficulty. His face had been somewhat distorted and there had been slight ptosis. In the affected eye there was a feeling of roughness, as though a grain of sand were beneath the lid, owing to a decided and persistent injection of the conjunctiva. Under various methods of applying electricity the patient slowly but manifestly progressed, but the injection of the conjunctiva with the harassing sensation of roughness yet remained. We now resorted to galvanization of the cervical sympathetic. This treatment, faithfully carried out, resulted in some general improvement, but the effect chiefly observed was a diminution, and ultimately an approximate cure, of the chronic injection of the conjunctiva, and the distressing sensation that accompanied it was entirely removed.

The result in this case was of special interest and peculiarly suggestive, since it seemed to confirm the deductions of physiological experiments, on the effect of electrization of the cervical sympathetic in causing contraction of the blood-vessels of the cerebrum.

Complicated case of nervous and uterine disease—Overpowering drowsiness, caused temporarily by short galvanization of the superior cervical ganglia.

CASE 5.—A lady past middle age (sent to us by Dr. Wey), who had been nearly all her life an invalid, suffering at first from uterine displacements with complications, and latterly from neuralgia of the head of the right thigh, was treated for more than two months by powerful faradic currents, variously applied to the spine and to the affected limb, without at any time experiencing any unpleasant or peculiar effects aside from a general weariness for a short period after each application. She had indeed become so thoroughly accustomed to the ordinary electrical applications as to be above the need of special caution or watchfulness in treating her. On one occasion, when she was in about her usual condition, we galvanized the cervical sympathetic with a current of moderate strength from fifteen elements. In four minutes from the beginning of the séance she began to feel a sensation of drowsiness that was overpowering, amounting almost to faintness. Somewhat alarmed by the suddenness and violence of the symptom, we cut short the application The drowsiness was not only so extreme as to be disagreeable, but was accompanied by a sensation of nausea and vertigo. The patient was allowed to rest, and in half an hour the unpleasant symptoms departed, leaving behind only a sense of extreme weariness. Cases of such exceeding susceptibility of the cervical sympathetic are, we believe, exceptional; and, with becoming caution, these temporarily disagreeable results can always be avoided by making the first tentative applications with a very moderate current, and of short duration. It is probable that if other cases had been treated as long as in the present instance, similar sensations might have been experienced.

Progressive muscular atrophy in muscles of left hand—Rapid and extraordinary acceleration of the pulse after galvanization of the sympathetic—Subsequent improvement under the same treatment.

CASE 6.—A lady of 20 years of age, affected with muscular atrophy of the left hand, that was gradually extending to the left finger of the right hand. The atrophy of the inter-ossei muscles was so complete that the hand had become a typical illustration of the so-called claw-hand, as described by Duchenne. The electro-muscular contractility and sensibility of the affected muscles was completely destroyed, and even the adductors of the thumb reacted only to a very powerful current. The hand was always exceedingly cold. The general health of the patient was apparently good, and the nutrition was quite well preserved.

After the patient had been for some time treated by peripheral faradization, we resorted to galvanization of the superior cervical ganglion of the right side. Although muscular atrophy is one of the conditions in which diplegic contractions have been frequently observed, yet in this case they did not appear. The pulse, taken just before the séance, was found to be 92. The application lasted between two and three minutes, and, while the electrodes were in position, no special effect was observed. Two minutes after the application the pulse, which before was 92, was found to be 130, and the hand, which was before cold, was found to be hot, and the face was flushed.

The patient soon left the office, and on her next visit reported that the febrile condition excited by the current was of but short duration.

In this case the sympathetic must have been in a condition of abnormal irritability or of actual disease, since in health such effects on the pulse are not produced even by prolonged applications. This case is of value, as tending to confirm the theory that progressive muscular atrophy is in some way dependent on, or associated with, disease of the sympathetic.

Anæmia with great debility—Paretic condition of muscles of hand—Immediate effect of galvanization of sympathetic.

CASE 7.—A gentleman, aged 45, became so exhausted by protracted disease that he was scarcely able to raise his arms to his head without assistance, and could not entirely close his fingers. The paretic condition of the muscles was evidently functional rather than organic. After other methods of employing electricity—central and peripheral, with both galvanic and faradic currents—had accomplished for him all that was possible, and the patient, though much benefited, had ceased to make progress under their influence, we began to localize the galvanic current in the cervical sympathetic. The immediate effect was to enable him to close his hand, and the séance was also followed by a sense of exhilaration that other forms of application had failed to produce. The faradic current, experimentally employed in precisely the same way, failed to exhibit any such effects. The relief, however, was mostly temporary; on the day following the applications he usually relapsed pretty nearly to his original condition. The treatment, continued for six weeks, caused decided amelioration that gave every hope of permanency; but, as is so frequently the case, the improvement stopped short at a certain point, beyond which it refused to be urged.

The application of electricity to prominent cervical ganglia is an interesting and suggestive, though not yet a well-defined auxiliary to diagnosis. The very decided tenderness that is revealed on electrization of the cervical ganglia, and occasionally of the solar plexus, indicates some disease either of the sympathetic or of some other portion of the system, but does not declare the precise nature or locality of the morbid condition. This tenderness—which is sometimes felt under any form of external pressure—has been observed in nervous dyspepsia, rheumatic gout, locomotor ataxy, muscular atrophy, neuralgia, myelitis, and during attacks of sick headache. The diminution of this morbid tenderness under treatment is usually accompanied by improvement in the condition of the patient. The relation of the so-called "diplegic contractions" to pathology or therapeutics is not yet determined.

The effects of faradization of the cervical sympathetic are not as decided as those of galvanization. That general faradization, however, does affect the sympathetic to a certain extent, seems to be pretty well established both by clinical experience and by its observed effects on the pulse. (See page 229.)

To lay down precise and exhaustive indications for the use of galvanization of the sympathetic is, in the present state of our knowledge of the physiology and pathology of this system, obviously impossible; the best guide to these indications is experience. The general indications for the use of this method of treatment to which experience would seem to point are these :—

1. Cases in which the sympathetic is itself diseased. Paralysis of the sympathetic, though not a frequent affection, is nevertheless one that is believed to occur, and to be quite amenable to galvanization. The sympathetic has also been found diseased in progressive muscular atrophy.

2. Cases in which the sympathetic is in a condition of abnormal irritability, a condition which is revealed by the effects of galvanization, and especially by the diplegic contractions. This condition is most frequently found in hysteria, locomotor ataxy, muscular atrophy, lead poisoning, and spinal irritation. In all of these diseases, galvanization of the sympathetic proves to be of essential service.

3. Cerebral hyperæmia. This condition is associated with and is a part of a large variety of diseases. Insomnia, hemiplegia, tic douloureux, many diseases of the eye and ear, as neuro-retinitis, nervous deafness and tinnitus aurium, are all more or less associated with cerebral hyperæmia, and all have been successfully treated by galvanization of the sympathetic.

4. Disorders of the vasa-motor nerves. Under this head may be included some cases of deficient circulation, cutaneous hyperæsthesia, and certain diseases of the skin.

5. Functional diseases of the digestive and genital apparatus. Galvanization of the sympathetic in these conditions seems to work, partly at least, by reflex action, and partly, also, by the influence which the spinal cord and pneumogastric receive during the applications.

It is scarcely necessary to remark that the exclusive use of galvanization of the sympathetic is indicated only in exceptional cases. It is to be employed in connection or alternation with general electrization and galvanization of the spinal cord, and periphery. A noteworthy advantage of this method of treatment in those cases for which it is of service is the comparatively short time required for its employment.

CHAPTER XVI.

THE NERVOUS DIATHESIS.

By the term nervous diathesis we design to express a constitutional tendency to diseases of the nervous system. It includes those temperaments commonly designated as nervous, in whom there exists a predisposition to neuralgia, dyspepsia, chorea, sick-headache, paralysis, hysteria, hypochondriasis, insanity, or other of the many symptoms of disease of the central or peripheral nervous system. What the gouty and scrofulous diathesis is to the blood, such is the nervous diathesis to the nerves.

The characteristic features of the nervous diathesis are :—

1. A fine organization. The fine organization is distinguished from the coarse by fine, soft hair, delicate skin, nicely-chiselled features, small bones, tapering extremities, and frequently by a muscular system comparatively small and feeble. It is frequently associated with superior intellect, and with a strong and active emotional nature. By these general features the fine organization is so positively distinguished from one of an opposite character that it is most readily recognized even by those least accustomed to the study of temperaments. It is the organization of the civilized, refined, and educated, rather than of the barbarous, and low-born, and untrained—of women more than of men. It is developed, fostered, and perpetuated with the progress of civilization, with the advance of culture and refinement, and the corresponding preponderance of labor of the brain over that of the muscles. As would logically be expected, it is oftener met with in cities than in the country, is more marked and more frequent at the desk, the pulpit, and in the counting-room, than in the shop or the farm.

2. Liability to varied and recurring attacks of diseases of the nervous system. The nature of these attacks and the frequency of their

repetition will be variously modified by climate, the seasons, and other external conditions; by the personal habits and manner of life, and especially by sex and age. The typical manifestations of the nervous diathesis in infancy are convulsions, irritability, and sometimes grave cerebral disorder; of childhood, chorea, and analogous symptoms; of puberty, headache, chlorosis, spermatorrhœa, and occasionally epilepsy; of maturity, sick-headache, neuralgia, dyspepsia, with its accompaniments, constipation, insomnia, nervousness and emaciation, functional and reflex, and occasionally organic paralysis, hypochondriasis, neurosthenia, and, in women, hysteria, spinal irritation, and the long train of nervous conditions associated with diseases of the organs of reproduction; of old age, softening of the brain and organic paralysis. A child born with nervous diathesis may suffer in infancy from attacks of spasms of the glottis; in childhood, from chorea; at puberty, from spermatorrhœa; between the age of twenty and fifty or sixty, from the different grades and forms of dyspepsia and neuralgia; and, in old age, may be suddenly removed by an attack of apoplexy, or gradually fail beneath the slow advance of cerebral softening or degeneration.

3. Comparative immunity from ordinary febrile and inflammatory diseases. The nervous diathesis appears, within certain limits, to *protect* the system against attacks of fever and inflammation. It is a matter of just and common observation that individuals of nervous organization are less liable to be attacked by fevers and general inflammatory conditions than the phlegmatic, the plethoric, and the hardy. It is furthermore observed that when once a fever—as typhoid, malarious, or rheumatic—has seized hold of a patient with the nervous diathesis, it is much less violent and less frequently fatal in its attacks than when its victim is muscular and full-blooded. We are sufficiently acquainted with the nature of fever to know that it is attended with rapid combustion. It is obvious, therefore, that the severity and intensity of a febrile attack on the body must, to a certain extent, depend on the quantity and quality of the combustible material of which that body is composed.

There seems, indeed, to be something in the nervous diathesis which is *antagonistic* to the febrile conditions, or at least to those forms which are developed by ordinary malaria, for it is certain that on the average (with numerous exceptions, of course, on both sides) fevers and inflammations are less fatal among brain-workers than among muscle-workers, even when subjected to the same exposure. Now it is among the brain-working class that the nervous diathesis is most distinctly marked and most frequently observed.

This great law also applies to races and nations. Although the question is so complicated by differences of external conditions that it is impossible to establish by statistics the relative quantity and quality of disease in civilized and barbarous lands, yet history and general observation seem to show that nearly all savage tribes are more liable to fatal attacks of certain forms of inflammatory and febrile disease than the civilized. The history of the North American Indians seems to point to this fact with considerable conclusiveness. Making all proper allowance for the better sanitary conditions, the higher prudence, and the stronger force of will of the civilized man, it would appear that he is less liable to contract certain forms of inflammatory disease than the barbarian, even when exposed to the same influences.

The nervous is the prevailing diathesis in the United States.

In this country, more than in any other, are observed the manifold phases of dyspepsia, neuralgia, insomnia, and nervous exhaustion, especially among our brain-working population. The fact that the women of America are more fragile and nervous than those of England and the Continent, and lose their beauty earlier, has long been recognized.

The causes of the greater prevalence of the nervous diathesis in the United States are not entirely obvious, but may probably be referred to these heads:—

1. Climate.—*Dryness* of atmosphere has been regarded as the principal cause of the peculiar nervousness of Americans, but this explanation seems to beg the question, for why should the nervous force be exhausted more rapidly in a dry than in a moist atmosphere? The fact that the atmosphere of the United States is both dryer and clearer than that of Europe is, we

believe, unquestioned, and is easily evident even to superficial observation. It has long appeared to us that this acknowledged nerve-exhausting tendency of a dry climate might perhaps be explained by the relation between atmospheric humidity and atmospheric electricity, and the very interesting researches of Wislizenus* of St. Louis would seem, so far as they go, to confirm this theory. (See Electro-Physiology, pp. 93–95.)

For the present, however, this view must be considered somewhat speculative.

2. *Dietetic habits and excessive activity.*—The Americans proverbially eat more rapidly and with less comfort than the English, French, or Germans. We take less time at our meals, and mingle with our eating much less of the social element, and toil more anxiously and nervously. While it is probable that these nervous and careless habits are the result of the climate, their chief explanation lies in the exigencies and necessities of our pioneer life, that has compelled us to be extremely provident of time. Furthermore, on account of the lack of pure native wine, and the almost universal adulteration of liquors, together with the popularly received views on total abstinence, most of our people are without any mild alcoholic beverage, and are, therefore, driven to an excessive and disproportionate use of tea and coffee. The American works more intensely, concentrates a larger amount of thought, anxiety, and action in a day than the foreigners. Inasmuch as we are all descendants of Europeans—since in our veins runs the blood of the portly Englishman and the stolid German, even more than of the sprightly Frenchman—it is fair to infer that the greater nervousness and intense activity developed on this continent are the result of our climate and the necessities of a new country.

This difference in character between the American and his European ancestors is suggested and confirmed by a corresponding difference in physique. Truly says Palfrey, in his history of New England: "The curly hair, moist skin, and sanguine temperament, so general in Great Britain, have in New England given place to straight hair, dry skin, and the nervous or bilious temperament."

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* *Vide* paper of Wislizenus in Transactions of St. Louis Academy of Medicine.

The remark of Emerson, also, that one hundred Englishmen would weigh one-quarter more than an equal number of Americans, must be approximately correct.

Correlation of Nervous Diseases.—There would appear to be cogent reasons for the theory that the law of correlation and conservation of forces is as true of disease as of health. The recognized relation that exists between certain cutaneous affections, as the manifestations of cerebral or other disease that appear in children, frequently, on the disappearance of an eczematous eruption; the relief of dyspepsia, of neuralgia, hypochondriasis, on the appearance of affections of the skin of various kinds in different parts of the body; the sudden metastasis of pain from one region to another, as from the hands to the feet, from the back to the limbs, from the stomach to the head, and alternations of sick-headache and indigestion, of cerebro-spinal and gastric disturbance with which nervous patients are so familiar; the mysterious phenomena of inheritance, by which the nervous diathesis that appears in the parent in the form, for example, of insanity, reappears in one child as chorea, in another as epilepsy, in another as hysteria, in another as neuralgia or paralysis, and successively reappears by almost innumerable phases in distant generations; the antagonism which certainly exists between nervous and febrile affections; the relief or cure of nervous symptoms, amounting to a revolution in the system, that results from a course of fever, or acutely inflammatory disease; and, finally, the very remarkable results that flow from counter-irritation, by whatever means produced,—all these facts of general observation, taken together, would seem to give weight to the theory that the secret forces of diseases are as truly correlated to each other as heat or gravitation, as magnetism or electricity.

The nervous diathesis should be distinguished from the tuberculous, with which it is frequently combined, and with which also it is liable to be confounded. The external appearances of the two are not very dissimilar, but their symptoms and their behavior under exposure, and especially their prognosis when existing separately, are radically different. The tuberculous diathesis frequently accompanies a fine organization; but fine organizations only in a certain proportion of cases have a tuberculous diathesis. The nervous diathesis is frequently not only not susceptible to tuberculosis, but apparently much less so than the average, and sometimes, indeed, seems to be antagonistic to it, for there are many nervous patients in whom no amount of exposure or hardship or imprudence seems to be able to develop phthisis, although they may appear to suffer intensely and constantly from the various phases of nervous disease. The tuberculous diathesis frequently appears in the coarsely organized, the plethoric, and the muscular.

It develops most rapidly and perhaps commits its greatest ravages among the poor, the oppressed, and degraded. On the contrary, the nervous diathesis, though found more or less among all classes of civilized lands, is chiefly found among the higher orders. Both of these diatheses are the results and concomitants of depressed vitality; but the nervous is peculiar to brain-workers and civilization, while the tuberculous also afflicts the day-laborer and the savage. The one is perhaps an impoverishment of the blood, the other an impoverishment of the nervous force.

The distinction between the nervous and the tuberculous diathesis is seen again in the contrast in their prognosis. The nervous diathesis in many of its manifestations is speedily relieved, but rarely permanently eradicated; the tuberculous diathesis is less susceptible to actual relief, but in occasional instances may be absolutely cured. The nervous diathesis, by protecting the system against inflammations, seems to lengthen life; the tuberculous, by attacking and destroying a vital organ, most fearfully shortens it. Both are best treated by tonics; but the tuberculous diathesis is to be treated through the blood, the nervous through the nervous system. In both the conflict between the remedies and the disease is always hard and sometimes long; in the nervous diathesis it is a guerrilla warfare, in which there are frequent skirmishes, with continual fightings and retreatings, where the enemy is disinclined to concentrate his forces or allow himself to be drawn into a decisive encounter. In the tuberculous diathesis it is a pitched battle for the possession of a vital organ, where the enemy fights behind intrenchments and usually obtains the mastery.

The general observation that the nervous diathesis is not inconsistent with long life is re-enforced by the fact, which statistics have now indisputably established, that the average longevity is nowhere greater than among the brain-workers—the very class in which the nervous diathesis and the numberless diseases to which it gives rise most frequently appears ; and also by the fact that the average longevity has increased such an enormous percentage with the progress of civilization.*

A very interesting fact connected with the nervous diathesis is that patients in whom it exists are sometimes positively benefited by attacks of febrile and inflammatory disease.

This is indeed one of the very few of the popular impressions on the subject of medicine that appear to be sustained by scientific observations. The genial Dr. John Brown, in the sketch of his father's memoir, uses the following language :—

"Many a man's life is lengthened by a sharp illness ; . . . a brisk fever clarifies the entire man. Such a breathing time my father never got during that part of his life and labors when it would have availed most."†

Inflammations seem to act antagonistically to the nervous diathesis on the principle of counter-irritation. The theory that they, in some way, derive from the nervous to the vascular system is certainly plausible, though it cannot be satisfactorily demonstrated.

We have made these remarks on the nervous diathesis, because it is the condition of the system for which electrization is mainly indicated. The majority of the patients that seek treatment of the electro-therapeutist are those in whom this diathesis predominates, whatever may be the special disease or symptom from which they immediately suffer. Most of the cases of nervous dyspepsia, nervous exhaustion, chorea, and insomnia, and very many of the cases of central and peripheral paralysis, are but manifestations of the nervous constitution, and are to be treated accordingly, that is, by remedies directed to the general system as well as to the local symptom. The failures that are experienced in the use of electrization for local nervous symptoms are frequently due to this fact, that the relation of the local symptom to the nervous diathesis is not recognized or appreciated by the operator.

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* The detailed arguments and statistics on the whole subject of the relation of mental labor to health and longevity will be presented in Dr. Beard's *Hygiene for Brain-workers*, now in press. For the present the reader is referred to his essay on the subject in the October number of *Hours at Home*, 1867 ; to the articles of Dr. Edward Jarvis on the *Increase of Human Life*, in the *Atlantic Monthly* for October, November, and December, 1869 ; to the statistics of Hon. B. G. Northrop in the *Annual Report of the Board of Education of the State of Conn.*, 1870, pp. 61–74.

† Spare Hours, by John Brown, M.D. Am. ed., pp. 206, 207.

The wide prevalence of the nervous diathesis and *its relation to local symptoms helps to explain what to many appears so unaccountable and inconsistent, that electrization is of service in so many diseases.*

The nervous diathesis demands a stimulating tonic treatment, and therefore electrization is indicated for all its phases and manifestations, whether it appear in the form of dyspepsia or insomnia, of hypochondriasis or hysteria, chlorosis or chorea, paralysis or neuralgia, grave organic disease or simple nervous exhaustion.

In all of these diseases, and in nearly every possible phase of the nervous diathesis, electrization in its different forms and methods of application is successfully used, not because it is a specific for all, or indeed for any one, but because it fulfils better than any other single remedy the one great indication which is common to them all—*the improvement of local and general nutrition.*

CHAPTER XVII.

NEURASTHENIA, OR NERVOUS EXHAUSTION.

THE morbid condition or state expressed by this term has long been recognized, and, to a certain degree, understood, but the special name *neurasthenia* is now, we believe, for the first time presented to the profession.

It is quite recently, indeed, that the phrase nervous exhaustion has been popularized, at least as a term expressive of any special condition of the system. Prof. Austin Flint* devotes a brief space to this subject, and acknowledges his indebtedness to Dr. Fordyce Barker for first suggesting the phrase "*nervous asthenia*" as expressive of a special morbid condition. Besides this brief notice of Prof. Flint, this important condition of the nervous system has not, so far as we know, been dignified by a separate heading or distinct chapter in any of our most approved treatises on the Practice of Medicine, although the general phrase "*nervous exhaustion*" quite frequently occurs in conversation and medical literature, and is now the common property of the profession.

This nomenclature would seem to be justified by philological analogy and by scientific convenience.

The derivation of the term *neurasthenia* is sufficiently obvious. It comes from the Greek νευρον, "a nerve," α, privative, and σθενος, "strength;" and, therefore, being literally interpreted, signifies want of strength in the nerve.

The character of this malady, if we be allowed to call it such, may best be understood by comparing and contrasting it with *anæmia*, a condition with which it is frequently associated as cause, effect, or concomitant.

Anæmia (derived from α, privative, ν, euphonic, and αἷμα, "blood") is to the vascular system what *neurasthenia* is to the ner-

* Principles and Practice of Medicine, p. 640.

vous. The one means want of *blood;* the other, want of *nervous force.*

Both anæmia and neurasthenia may be the *effects* of acute or chronic diseases, and both may be either acute or chronic in their course. Thus neurasthenia may be the effect of wasting fevers, exhausting wounds, parturition, protracted confinement, dyspepsia, phthisis, morbus Brightii, and so forth. Anæmia, as is well known, may result from the same diseases.

Both anæmia and neurasthenia may also be the *cause* of chronic and acute diseases. Thus neurasthenia, or nervous exhaustion, may give rise to dyspepsia, headaches, paralysis, insomnia, anæsthesia, neuralgia, rheumatic gout, spermatorrhœa in the male, and menstrual irregularities in the female. Anæmia also is the source of many of these diseases, though, perhaps, it is more frequently the effect.

Anæmia and neurasthenia may cause each other; anæmia is often the result of neurasthenia, and *vice versâ.*

Both anæmia and neurasthenia are most frequently met with in civilized, intellectual communities. They are a part of the compensation for our progress and refinement.

Anæmia and neurasthenia may run into each other, and become so closely blended that it is oftentimes impossible to determine which was the cause and which was the effect, or which is the ruling condition.

Both of these conditions, whether existing separately or in combination, are best treated by some form of constitutional tonics. In anæmia we give those tonics that directly and specially affect the *blood;* in neurasthenia we give those remedies that directly and specially affect the *nervous system.*

Neurasthenia, in a certain sense, is to all periods of life what chlorosis is to the period of puberty, since, like chlorosis, it is a disease of the nervous system, and as such is to be distinguished from anæmia, which is a disease of the blood.

The distinctive features of neurasthenia may perhaps be best understood by placing them side by side with those of anæmia, which it so nearly resembles, and with which it is so frequently associated.

Neurasthenia.	*Anæmia.*
Chiefly found in nervous diathesis.	Appears also in the tuberculous, or rheumatic, or other diathesis.
Impoverishment of nervous system, *no necessary anæmia. Patient may be plethoric.*	Impoverishment of the blood; increase of water, and diminution of red corpuscles.
Not at all necessarily dependent on any important recognizable organic disease.	More frequently, though not necessarily, associated with some organic disease, as tuberculosis, carcinoma, morbus Brightii, &c.
Pulse may be full or normal, usually regular.	Pulse small, weak, and compressible.
No cardiac murmurs.	Murmurs at the base of the heart and over the larger arteries, as the carotid, subclavian, &c. "Venous hum" in the neck.
No pallor—sometimes even a rubicund appearance.	Very perceptible pallor of the face, especially of the lips.
Easily fatigued by exertion; *mental* labor more exhausting than *physical.* Memory often temporarily weakened, and consecutive thought and sustained mental activity frequently impossible, *even when prolonged muscular labor causes little or no fatigue.*	Easily fatigued by exertion. *Physical* labor more exhausting than *mental.*
Insomnia a very frequent complication.	Insomnia not so frequent a complication.
No necessary disturbance of the circulation.	Disturbance of the circulation, with habitually cold extremities.
Habitual mental depression.	Mental depression not so frequent.
Though common to both sexes, not so relatively frequent in females.	Far more frequent in females.
Is benefited by remedies that directly affect the nervous system, such as phosphorus, strychnine, while iron alone is of little service.	Is benefited by remedies such as iron, that directly affect the blood.
Usually recovers but gradually, and under the influence of rest, nutritious food, and nervous tonics.	May be rapidly removed by the removal of the organic cause.

Both conditions may be characterized by disturbances of the digestion, and both may be complicated with almost any conceivable form of disorder. It should be considered that in the above comparison we have supposed cases so far as possible simple, typical, and uncomplicated.

The *diagnosis* of simple and pure neurasthenia, like all of the so-called functional conditions, is arrived at mainly by *exclusion.*

In any case presenting the leading features above described as characteristic of neurasthenia, it is necessary, *first*, to exclude any organic disease which could account for the symptoms, and, in the second place, to exclude anæmia, with which it would most likely be confounded.

Many cases of spinal irritation and hysteria are likely to be classed as simple nervous exhaustion. Symptoms of neurasthenia frequently arise from organic diseases of the brain and spinal cord, and especially at their incipience do not directly suggest their origin. The premonitory stages of locomotor ataxy, myelitis, of spinal irritation, and indeed of the various grades of anæmia and hyperæmia of the central nervous system, are sometimes so similar to those of simple neurasthenia that the diagnosis must remain a matter of doubt until elucidated by the history of the case.

Under the recent advances in the method of studying disease, many cases that were once vaguely described as general debility, or "nervousness," are now known to be of a definite and organic character. It is therefore fair to suppose that neurasthenia or nervous exhaustion, which, like hysteria, chlorosis, &c., is at best a mere cover for our ignorance, will be supplanted by some other term which may perhaps more correctly express its pathology. Even with our present means of diagnosis, cases of uncomplicated neurasthenia are by no means frequent.

In regard to the pathology of neurasthenia we are compelled, in the absence of definite knowledge, to reason from logical probability.

The central nervous system may become dephosphorized, or, perhaps, loses somewhat of its solid constituents; probably also undergoes slight, undemonstrable morbid changes in its chemical structure, and, as a consequence, becomes more or less impoverished in the quantity and quality of its nervous force.*

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* *Vide* the pamphlet on the Correlation of the Physical and Vital Forces, by Prof. George F. Barker. New Haven, 1870.

In regard to the precise seat of the exhaustion, it is reasonable to infer that it may be in the *brain*, or *spinal* cord, or *sympathetic*, or it may be general in its character.

That molecular disturbance, sufficient to give rise to the symptoms of nervous exhaustion, may take place in the central nervous system, is rendered logically probable by the fact that such changes can be produced artificially, as proved by the researches of Du Bois-Reymond.*

We are, we think, driven to accept this view from what we know of the brain and spinal cord—of their relation to the intelligence and activity, of their intimate chemical structure, of their diverse appearances in health and disease. We know that the intelligence of men and animals is proportioned to the quantity and quality of the cerebral contents; that the proportions of water, of phosphorus, of fat, and of the other solid constituents of the central nervous system, vary more or less with the age and with the intellectual and moral capacity,† and that all forms of insanity‡ are dependent on some central morbid condition.

From these established facts we logically conclude that even the slightest and most transient disturbances of the nervous system are the symptoms and expression of correspondingly slight morbid changes of the brain or spinal cord, sympathetic, or of the peripheral nerves.

We admit that this view is speculative, but it is not impossible, we feel assured, that it will in time be substantially confirmed by microscopical and chemical examinations of those patients who die in a neurasthenic condition. We have all experienced the temporary exhaustion that results from prolonged intellectual exertion: make this condition *chronic*, and we have neurasthenia.

Neurasthenia may result from any causes that exhaust the nervous system.

Hereditary descent.—The nervous diathesis terribly predisposes to neurasthenia, just as it predisposes to all forms of nervous derangement. The law of *reversion* is frequently illustrated here, and sick-headache, epilepsy or insanity or dyspepsia in the grandfather may skip over a generation and show itself as neurasthenia in the grandchildren. Among the special exciting causes of neurasthenia may be mentioned the pressure of bereavement, business and family cares, parturition and abortion, sexual excesses, the abuse of stimulants and narcotics, sudden retirement from business, and civilized starvation, such as is sometimes observed even among the wealthy orders of society. *The disease is most frequently found in the United States, among the brain-working classes of our large cities.*

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* Reynolds' System of Medicine, vol. ii., p. 48.

† See analysis of L'Héritier, quoted in Prof. Draper's Physiology, p. 273.

‡ Maudsley's Physiology and Pathology of the Mind, p. 59.

The one principle on which neurasthenia is to be treated is by the concentration of all possible tonic influence on the nervous system—air, sunlight, water, food, rest, diversion, muscular exercise, and the internal administration of those remedies, such as strychnine, phosphorus, arsenic, &c., which directly affect the central nervous system.

Electrical Treatment.—General faradization and central galvanization. All of our cases have been treated mainly by general faradization, with the occasional one of galvanization of the sympathetic.

The *prognosis* is usually more or less favorable. In nearly all cases of uncomplicated neurasthenia general faradization alone proves decidedly and sometimes rapidly efficacious. Beneficial results are so uniform in this condition that we have reason to suspect some unrecognizable organic disease in those cases that give no evidence of improvement after protracted treatment. Even the complicated forms, that are the result of incurable disease, may be much relieved. Some cases, as we shall see, though temporarily relieved, may go on to positive and recognizable disease of the brain or spinal cord.

Neurasthenia—Debility and attacks of sick-headache—Immediate and rapid improvement under general faradization—Rapid increase in weight.

CASE 8.—The power of general faradization to relieve neurasthenia and to cause increase of weight, was illustrated in a very pleasing and satisfactory manner in the case of a young physician whom we have treated during the autumn of 1869. He was 28 years of age, and for a long time he had been subject to severe and repeated attacks of nervous and sick headache. To use his own expression, he had been "living on a lower plane than was normal." Over-work and long confinement had reduced him to a condition of serious exhaustion, and when he called upon us in September he could not walk two miles without fatigue. Although 5 feet 9½ inches in height, he weighed but 112 pounds, and for many months there had been no sign of any increase. He had closely studied his own case, had been thoroughly examined, and had tried nearly every form of internal medication.

We began treatment by a mild application of electrization with the faradic current. He felt temporarily enlivened and exhilarated, but when he returned, two days subsequently, he stated that he felt no special benefit, although he had gained *one-half a pound in weight.* This change, slight as it was, encouraged him, for it had been months, and years even, since he had been able to detect any increase in weight. We may say here that he watched and studied his symptoms, and carefully ascertained his weight, from day to day, not as a hypochondriac at all, but as a scientific man, inspired not by any special faith in the remedy, but by an earnest desire to test for himself the tonic effects of general electrization. He continued to increase in weight with remarkable regularity and uniformity, and at the end of three weeks he found that he had increased nine pounds. When we last saw him his weight was 124 pounds. The improvement in his general condition had gone on hand in hand with the increase in weight. His appetite was keener and his digestion much easier. His attacks of headache still annoyed him, but his capacity for endurance had been greatly enlarged. Whatever relapses may occur in coming months or years, he feels now that he has at least found a means of relief and permanent benefit.

In this case the applications were made very thoroughly all over the person, from the top of the head to the feet, and with a powerful current. Both the faradic and galvanic currents were used, chiefly the faradic. It is worthy of remark, also, that this patient always experienced a feeling of temporary enlivenment and exhilaration after each application, and sometimes the headache from which he suffered was driven away in the midst of the treatment.

We may say, also, that when he first came we prescribed oxide of zinc, by *exclusion,* because he had used nearly every other internal tonic. He took, however, two or three doses of one grain each for the first day, dropping it entirely as soon as he found that he had increased half a pound in weight.

This case we regarded as pre-eminently a typical one—a typical illustration of neurasthenia, and of the benefit that may be received from general electrization.

Nervous exhaustion of three years' standing, associated with insomnia, aberration of memory, and night sweats—Complete recovery in two months, after the administration of twenty applications of general faradization.

CASE 9.—C. McC., aged 19, a patient of Dr. D. B. St. John Roosa, was referred to us as a typical case of nervous exhaustion, associated with insomnia, aberration of memory, and night sweats.

These symptoms were first manifest some three years since, when the patient was working as a machinist. As all remedies were without apparent effect, he was obliged to relinquish his trade for lighter work. He suffered from paroxysmal seasons of intense depression, and at such times was tortured with the dreadful thought of ending his own existence. These singular attacks usually came on about noon each day. There was no indication of organic disease, and as the usual tonic remedies had been faithfully taken, the patient was submitted at once to the tonic influence of general faradization.

In few cases have we seen more decided and satisfactory results than in this. Strength seemed to be at once imparted to the whole nervous system, and in less than two months, after having received some twenty applications, he quite recovered from every unpleasant symptom.

During the two years since recovery there has been no indication of a relapse.

Nervous exhaustion and insomnia—Debility of long standing—Great benefit from general faradization and galvano-faradization—Relapses.

CASE 10.—Mr. E. H., aged 43, tall and spare, President of a Fire Insurance Company, consulted us Nov. 14, 1868, after experiencing an indefinable attack of cerebral congestion, which had caused him considerable alarm. For many years he had suffered from dyspepsia, constipation, and cephalalgia, and more recently from insomnia. The duties of his office had been irksome; calculation, writing, consecutive thought, wearied him. A long walk was followed by exhausting fatigue. There were evidences of anæmia, but no symptoms that pointed to any specific morbid condition of the brain or spinal cord.

Electric examination.—Sensitiveness, but not marked or excessive, in the epigastric region.

Treatment by general faradization repeated every other day, beginning with mild, and increasing to strong applications. The symptom first to yield was insomnia, then the bowels became more regular, and in two weeks there was a decided increase of strength. Capacity for exertion, muscular and mental, was gradually developed. The muscles of the upper and lower limbs became harder and firmer.

Dec. 15 we began to use galvano-faradization, which, at first, caused a relapse, and subsequently aided the improvement.

Jan. 1, 1869, he had so greatly improved in all respects that further treatment was not indicated.

During the year 1869 the patient suffered two relapses—the first caused by excessive confinement, and the second by an exhaustive fever. Of the first relapse he was relieved by general electrization.

In the winter of 1870 the patient was again prostrated by unmistakable symptoms of cerebral disease.

Probable neurasthenia in a plethoric patient, caused by excessive application to *business—Slow improvement under galvanization and general fraadization.*

CASE 11.—Mr. A. was a short, stout, and remarkably plethoric man, aged 60. Through his active business life he had confined himself most closely to his duties, seldom taking a day for recreation, even during the heat of summer. Nineteen years since he retired from business with greatly impaired health and strength. It was thought that perfect freedom from all care would be sufficient to restore his native vigor of constitution. On the contrary, he gained but little, if any. His general appearance was typical of perfect health, but ordinary exertion, either mental or physical, was sure to produce exhaustion. *His pulse was normal, and the patient was plethoric rather than anæmic.* It was impossible for him to read more than ten or fifteen minutes without becoming restless and excessively nervous, and exercise in walking, to the extent of a dozen blocks or so, would frequently produce complete prostration. His sleep at night was broken, and sometimes entirely destroyed There was not the slightest evidence of organic disease, but the whole nervous system seemed to be unstrung. He had submitted to almost every method of tonic treatment, both medicinal and hygienic, but had seldom experienced even temporary relief. We felt justified in encouraging him to hope for favorable results from treatment by electrization. With admirable perseverance and promptness he continued to visit us for two months, never, in a single instance, failing to keep an appointment.

At first, general applications with the faradic current were given every other day. At each sitting he seemed much invigorated, and for several hours he experienced a degree of strength and lightness of spirit such as he had been a stranger to for years.

These effects, however, seemed but temporary, for the old lassitude invariably returned; consequently, after three weeks of treatment with the faradic, we resorted to a weak galvanic current, from twelve of Bunsen's cells.

The negative pole was applied to the epigastric region, and the positive to the back of the neck, near the seventh cervical vertebra and also along the anterior border of the scalenus anticus muscle, in order to affect more thoroughly the great sympathetic.

Sponge electrodes were used, and the applications were prolonged sufficiently to produce an intense redness and an acute burning sensation under them. By this method the immediate effects were not so marked as when the faradic current was used, but the relief afforded was more permanent.

For the first time, his sleep became more quiet and sound, and during the day following an application he was able to exercise both mind and body harder and longer than usual. He now submitted to treatment by galvanization every day. Week by week he gained very perceptibly in vigor, until, after having received the galvanic current some twenty-five times, he left us to spend the summer months among the mountains. He did not discontinue treatment with a nervous system perfectly strengthened, but he had regained approximately the usual portion of mental and physical endurance enjoyed by persons of his years. Whereas, before treatment by electrization, he was not able to walk half a mile without fatigue, nor read more than ten or fifteen minutes without suffering from nervous irritability, after treatment he enjoyed and derived benefit from walking several miles in the day, and could confine himself to a book for an hour or two without experiencing any symptoms of mental exhaustion.

The query arose whether, in the above case, there might not have been some cerebral difficulty. Subsequent history of the case would seem to justify the diagnosis of neurasthenia, since, at the date of writing, he is still in quite good health.

Neurasthenia, complicated with anæmia, dyspepsia, spinal irritation, and hypochondriasis, treated by general faradization and galvanization — Improvement and subsequent relapse.

CASE 12.—Mr. E., a tall, spare man, aged about 50, was sent to us by Dr. Gurdon Buck, to try the effect of electrization. He was a gentleman of wealth and leisure, and for several years had been entirely free from any of the cares of active business life. He was frequently troubled with indigestion. At times he would seem to regain some vigor, and would exercise to a considerable extent without experiencing inconvenience, but as a rule the most ordinary mental or physical exertion was followed by extreme exhaustion. Pains in the lumbar region of the back were of frequent occurrence, especially after passing a sleepless night. There was, however, no spinal tenderness. He was a good barometer—an east wind would almost drive him to despair, and so long as it lasted he could hardly muster strength or inclination to leave his couch. As soon as the wind changed and the sun appeared, he observed an immediate amelioration of his dreadfully depressed condition.

Our patient experienced the usual exhilaration that so frequently follows a general application of the faradic current.

Although at first this invigoration was of but temporary duration, the effects of the treatment were gradually prolonged after each sitting, until in a much shorter time than is usually the case in conditions such as the one under consideration, the patient enjoyed a good degree of health.

We noticed that while the faradic current was more effectual than in the case of Mr. A., just related, the galvanic current seemed to possess even greater power.

During damp, enervating days especially, general galvanization prevented exhaustion far more successfully than faradization. The patient retained the nervous vigor that he had gained for many months; subsequently, however, he relapsed, and again placed himself under our care. He was decidedly benefited by this second course of treatment, but not to the same extent as at first. When last seen he had retained a measure of improvement, but was extraordinarily susceptible to atmospheric changes.

Neurasthenia caused by anxiety—Insomnia, great debility, treated by general faradization—Temporary improvement with relapse.

CASE 13.—Dr. C. L. Mitchell, of Brooklyn, requested us to see with him a very interesting and unusual case.

The patient was a married lady of refinement and culture, endowed with an exquisitively sensitive organization.

We found her in bed, unable to walk across the room, or even to make the slightest exertion without experiencing fatigue. Her pulse was weak and the appetite capricious. For a long time she had suffered from persistent insomnia, which greatly aggravated her distress.

No organic disease was manifest, yet her physician, at short intervals, anxiously tested her urine for evidence of Bright's disease. The history of the case is as follows: During the summer of '67 she became considerably reduced in strength and spirits.

In the early part of November of the same year she began to suffer from insomnia and great nervous prostration, which in a short time so reduced her that she was confined not only to the house, but most of the time to her bed. Skilful medical treatment, the most tender care, and the best possible hygienic surroundings alike proved unavailing. For several months she remained in about the same condition, her symptoms being neither aggravated nor much improved.

Sleep was produced only by the administration of large doses of McMunn's elixir of opium, which fortunately caused no derangement of the digestive function.

Bromide of potass. was entirely inoperative; probably because of excessive cerebral anæmia. A short time previous to her illness she had experienced intense anxiety, because of the simultaneous and serious illness of her five children. To this cause in a great measure was attributed the nervous prostration from which she had long continued to suffer.

We made the first application of an exceedingly mild and fine faradic current over the head down the spine, Jan. 28, '68. The séance lasted but about 5 minutes.

The patient described the sensation as most delightful, and expressed disappointment because the treatment was so brief. The following night she slept better and longer than usual. In two days a second visit was made, and although in the mean time the menses had appeared, we gave her mild treatment as before. The immediate result was unfavorable, for such a profuse flow was caused that she was greatly weakened, and it was necessary to suspend treatment for nearly a week.

By February 5th the patient had regained her usual strength, and we made a third application with greatly increased intensity of current.

February 8th, found her considerably improved. She felt stronger; her appetite was better, and she slept quietly, although her nightly dose of opium was reduced one-third. She retained what she had gained until February 22, when electrization was discontinued until March 4th, because of the return of the menstrual period. For seven nights after the last application (February 22d) she slept extremely well. For three nights preceding the next séance, March 4th, she suffered much from a return of the old persistent insomnia.

The 12th application was given March 6th, when treatment by electrization was discontinued.

She became discouraged by this last relapse, comparatively unimportant and readily accounted for, as is at once seen. One marked result of the effect of electrization was a considerable increase in the strength of the arms.

CHAPTER XVIII.

HYPOCHONDRIASIS (PATHOPHOBIA) AND MELANCHOLIA.

LIKE hysteria, dyspepsia, and insomnia, hypochondriasis is frequently one of the manifold phases of the nervous diathesis, and may be, and frequently or usually is, associated with some one or more of these nervous symptoms. It is a concomitant of spermatorrhœa, of disease of the liver, the spinal cord, and especially of the brain.

The special pathology of this symptom is rarely revealed, except in those cases where it is evidently dependent on disease of the brain.

We desire here to speak not so much of the melancholia of the severer stages of cerebral disease, but of the milder and more frequent forms, such as are exhibited in the incipient or premonitory stages of insanity, or as are daily familiar to all physicians as an accompanying symptom of dyspepsia, nervous exhaustion (neurasthenia), and spermatorrhœa.

Of the first class of cases the pathology is probably the same as that of insanity itself, and it results from some disease of the brain, the same in kind, differing only in degree from that which is found on *post-mortem* examinations of those who have died insane.

Of the second and far more numerous class of cases of hypochondriasis, such as are every day found in association with the nervous symptoms above mentioned, the pathology, we need hardly say, is both uncertain and obscure. There are potent reasons for believing that the sympathetic nervous system is largely at fault in such cases; and that if not demonstrably diseased, it is yet the *medium* through which disease of the other parts reacts on the brain, and produces molecular or other disturbance.

These reasons are :—

1. Hypochondriasis is most markedly and uniformly associated with disease of those organs that are liberally supplied with branches of the sympathetic. It is by far most frequently associated with diseases of the stomach and liver, and the genital apparatus. Now the stomach and liver are supplied by the great solar plexus, while the genital organs are supplied by the hypogastric plexus.

On the other hand, hypochondriasis is but rarely associated with disease of the lungs, even in the last stages of consumption; and we know that the sympathetic nerve supply of the thorax is but meager in comparison with that of the digestive and genital organs. It is familiar both to the laity and the profession that very slight disturbances of the urethra, prostate gland, of the testicles, of any or all parts of the genitals, may give rise to the most obstinate and depressing melancholy, which is ludicrously out of all proportion to the character of the disease; while, on the contrary, patients whose lungs are hollowed by wasting tubercles, and whose days are certainly numbered, not only do not despond, but are irrationally and absurdly hopeful.

2. The demonstrated and established fact that hypochondriasis frequently yields to electrization of the sympathetic ganglia, goes strongly to show that this portion of the nervous system is either the seat of the disease or the medium of its communication.

The cases detailed hereafter will illustrate this point with sufficient fulness.

The two leading ideas that we here desire to impress are, *first*, that hypochondriasis is just as truly a disease, or, more strictly speaking, a symptom of disease, as dyspepsia, insomnia, chorea, neuralgia, paralysis, or insanity, and should be treated accordingly. The popular method of kicking hypochondriacs out of doors, administering *placebos*, is not scientific, and, except in rare cases, is not successful. *Secondly*, hypochondriasis, when not dependent on serious lesions of the central nervous system, is susceptible of relief and of positive cure under the skilful and faithful use of electrization. Still further we believe—and the results of our own cases justify the belief—that cerebral disease of a more pronounced character itself may be relieved by electrization; and that that terrible form of hypochondriasis which is the precursor of organic cerebral disease—the vestibule that leads to the dark and gloomy caverns of insanity—may be controlled or kept at bay by a persevering electrical treatment.

Prognosis.—Of 12 cases in which hypochondriasis was the leading symptom that we have treated, 3 recovered, 3 approximately recovered, 4 were decidedly benefited, and in one case the result was unknown.

Treatment.—In hypochondriasis both general electrization and galvanization of the sympathetic are indicated. We have obtained good results from both methods, though most of our cases were treated by the former. Galvanization of the brain and spinal cord may be used in cases that are supposed to depend on disease of these parts.

Persistent mental depression—Improvement under general faradization after galvanization of brain, sympathetic, and spinal cord had failed.

CASE 14.—The beneficial results of general faradization in hypochondriasis were decidedly manifest in the case of a patient directed to us by Dr. John T. Metcalfe. In the case under consideration there was not the slightest evidence of organic disease; every function was, as a rule, performed in a regular and healthy manner. The patient was a man in the prime of life, with a physique and countenance indicative of robust health.

For several months his daily life had been rendered miserable by an undefinable sense of oppression, and a fearful looking forward to of calamity and ruin.

In vain did he exercise all the philosophy and reason of a naturally well-balanced mind: his delusions clung to him, and the only waking hours to which he looked forward with any degree of patience were those of the early evening.

After a comfortable dinner and a few glasses of sherry his spirits invariably rose; for a time he was again himself. The patient was most persistent and faithful in submitting to treatment, and the number of applications that he received was somewhat extraordinary. Of the faradic current some 75 were administered. Occasionally we subjected him to galvanization of the brain, cord, and sympathetic, but the results of this method of treatment were by no means favorable. Under general faradization, however, he decidedly improved.

Pathophobia—Suspected disease of the ears—Improvement under general galvano-faradization.

CASE 15.—A still more favorable result was obtained in the person of a young man aged 25, who, like the patient just referred to, presented every indication of health. At all hours of the day he was annoyed by tinnitus aurium, and what to him seemed an audible voice telling him of evil to come. We submitted him to general applications of a powerful faradic current, and also to occasional galvanization of the brain, cord, and sympathetic. Some improvement followed. The most decided benefit was, however, derived from the method of galvano-faradization. The faradic current, full strength, from a Kidder apparatus, and at the same time the galvanic current from 15 cells of Bunsen's battery, were passed through and around the body, by the method of general electrization. Improvement was now remarkably rapid. In the course of half a dozen applications every unpleasant symptom disappeared, and the patient has since remained perfectly free from any evidence of their return.

Mental depression, insomnia, and loss of memory caused by excessive and protracted intellectual exertion—Temporary relief from a short treatment by general faradization.

CASE 16.—Mr. W., aged 65, was referred to us May 31st, 1869, by Dr. E. R. Peaslee. The patient was remarkably tall, large, and quite plethoric. He was a lawyer in large practice, and for many years had closely confined himself to his duties, with scarcely any vacation.

Recently he had observed impairment of memory, and was unaccountably depressed.

Treatment by general faradization was used five times, with special reference to the head, and with apparently beneficial results.

Gastralgia, insomnia, hypochondriasis, during convalescence from an attack of peritonitis—Approximate recovery under general faradization.

CASE 17.—Mr. B., aged 67, was first seen by us April 1, 1868. The patient a strong, firmly-built man, who had always been in pretty uniform health. All winter he had been confined to his house, and much of the time to his room and bed. At one time had experienced a severe attack of peritonitis, from which he recovered under treatment, but which left him in a condition of debility and nervous impressibility. He was dyspeptic, more or less sleepless, and exceedingly despondent. There were no evidences of local lesions, or of an organic disease, but considerable rheumatic pain in the muscles of the back, and occasional attacks of gastralgia. He was quite irritable, self-absorbed in his symptoms, and apprehensive of impending evil.

The first applications of general electrization were given at the patient's residence. His adipose tissue was abundant, and he bore strong currents without discomfort.

The improvement was immediate. After the second sitting he became more hopeful, and felt stronger. He soon began to walk and ride out; was less capricious and exacting in his diet. There was less tendency to magnify his physical evils and a greater consideration for the comfort of his attendants. On May 1st, he began a course of treatment at the office which resulted in still further improvement. By the middle of May he returned to his home entirely relieved of all his symptoms. Six weeks after there was a recurrence of attack of gastralgia, which disappeared during the summer. In this case the improvement, especially at the outset, was probably due in part to the moral influence of a new physician and novel method of treatment.

Insanity.—The very marked results that have been obtained by electrization in hypochondriasis, insomnia, and hemiplegia dependent on cerebral disease, give reason to hope that the same remedy may be useful in insanity. The incipient stages of mental disease ought certainly in some cases to be relieved, if not cured, either by faradization or galvanization of the head, and galvanization of the sympathetic. We believe that an important future is in store for the scientific, faithful use of this remedy in our public and private asylums.

It will be observed that a number of our cases of hysteria and hypochondriasis in which the results of treatment were most satisfactory, were really of unsound mind, and for this reason we regret not to have had opportunity to test the treatment in severer forms of insanity.

Althaus* reports good results in some cases of excessive spirit drinking from the use of galvanization of the spine, head, and cervical sympathetic. He states, that under this treatment "the morbid desire for alcohol was rapidly checked."

Dipsomania.—*Chronic Alcoholism.*—*Opio-mania.*—*Excessive Use of Tobacco.*—Electrization would be indicated in cases of excessive addiction to alcohol, opium, or tobacco, on two grounds. In the *first* place, the cerebral disorder with which these conditions are associated, and of which they may sometimes, at least, be supposed to form a part, would be benefited by galvanization of the head and of the sympathetic; and, *secondly*, the very great debility and nervousness that result from the excessive use of these agents, and which so severely complicate all attempts to break off the evil habit, would be rationally combated by general electrization. Althaus reports favorable results from this treatment in opium-eating and excessive smoking. The symptoms of chronic alcoholism are so similar, in many respects, to those that are found in other nervous diseases, that they might, logically, be treated in the same way.

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* A Treatise on Medical Electricity. Second Edition, 1870, p. 440, *et seq.*

CHAPTER XIX.

HYSTERIA.

HYSTERIA *is a phase of the nervous diathesis in which all parts of the nervous system are in a condition of abnormal irritability, which may manifest itself by the same local or general symptoms that arise from organic disease.*

There is scarcely a symptom of organic lesion, from general paralysis down to the slightest twitches of neuralgic pain, that may not arise from an excessively irritable condition of the nervous system. The name hysteria is one of the most unfortunate that has ever crept into medicine. It suggests the idea that the disease in some way arises from the female genital apparatus, although it is now well recognized that it may exist in the male as well as in the female sex, and only in a minority of cases is there a traceable and necessary dependence on sexual irritation. Even in cases where sexual disturbance is associated with hysteria, it may be an *effect* as well as a *cause*, or it may stand in both relations.

Concerning the pathology of the hysterical condition, it is logical to assume that the abnormal irritability which constitutes its principal feature is the result or expression of some definite and peculiar morbid process, which is just as truly an organic condition as though it could be revealed to chemistry or the microscope. In the absence of precise knowledge we may assume that hysteria is an exaggeration of neurasthenia, or nervous exhaustion,—a more advanced stage of nervous impoverishment,—a step lower in the process of degeneration. Both conditions are common to the nervous diathesis, and both may be the advances to local and recognizable lesion of the nerve-centres.

The symptoms of hysteria are really the symptoms of all nervous diseases, since it may simulate all. So truly and so frequently is this the case, that before establishing the diagnosis in nervous diseases, it is necessary, first of all, to exclude the possibility of hysteria.

The leading features which, in any given case of nervous disease, lead us to suspect the hysterical condition, are *the peculiar hysterical convulsions and the nervous diathesis. Female sex, excessive hyperæsthesia, psychological disturbances, either constant or occasional, in the form of depression, melancholy, or caprice; disease of the sexual organs; œdema of the joints; a transitory, changing, and metastatic character of the symptoms; and, finally, absence of other necessary evidences of organic disease.*

Among the other symptoms which are most frequently manifested by hysterical patients, may be mentioned motor paralysis, muscular contractions, anæsthesia, neuralgia, including cephalalgia and spinal irritation, aphonia, and various tonic and clonic cramps, amenorrhœa, fits of nervous coughing or vomiting, hiccough, incontinence of urine.

Electro-diagnosis.—Usually, though not necessarily, there is excessive sensitiveness to the electric current in all parts of the body. Patients sometimes can bear only the mildest currents. In some cases even a mild current will not be borne on the middle of the back, which, in health, is usually so little sensitive. Reflex sensations may be observed during electrization of hysterical patients. Irritation of the diseased side of the body may be sensitively felt in the healthy side. *Another point in the diagnosis is the capacity for bearing very strong currents without injury, even when there is great hyperæsthesia.* The electro-diagnosis of hysterical paralysis will be presented under that disease.

Treatment.—Hysteria is a constitutional disease, and demands constitutional treatment. To attempt to chase after and direct the application of electricity to each special symptom as it appears, is unphilosophical and usually unsuccessful. General faradization and galvanization of the sympathetic are methods of electrization that are indicated for hysteria. Under whatever symptoms it may be developed, our chief and best results have been obtained by general faradization alone. This general treatment does not, of course, dispense with localized electrization of paralyzed muscles, or special attention to any localities where the disease is for the time directed. Diseases of the sexual organs, hysterical hiccough or cough, aphonia, or incontinence of urine, may sometimes need localized electrization, but these symptoms frequently yield under general electrization, when no special attention is given to the diseased parts. In nearly all cases, except, perhaps, long-standing paralysis, it is much better to dispense with the local than the general treatment. In cases of extreme hyperæsthesia, it may be necessary, as Benedikt* advises, to place the patient under the influence of an anæsthetic while the application is made. Strong currents do not appear to be injurious in such cases.

Prognosis. — The behavior of hysteria under electrization is as capricious and inconsistent as are its symptoms. Some cases yield to general electrization with wonderful rapidity; others, apparently no worse, are singularly obstinate. On the average, the prognosis is so favorable that no case should be abandoned without a fair trial of this method of treatment. Under peripheral electrization the results are usually unsatisfactory, since the relief of the local symptom is by no means a cure of the morbid constitutional condition.

Our records of hysteria are :—

Whole number treated	12
Recovered	4
Approximately recovered	1
Decidedly benefited	3
Slightly "	1
Not "	2
Unknown	1

Besides these, some of the cases reported under paralysis, anæsthesia, spinal irritation, anæmia, chlorosis, etc., may be regarded as more or less of an hysterical character.

Hysteria of a psychical origin—Paroxysms of weeping—Pain in the ovarian region—Great hyperæsthesia—Improvement under general faradization.

CASE 18.—The case of a young unmarried lady under the professional care of Dr. H. Gregory, of Harlem, very well illustrated some of the main points of the above remarks.

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* Op. cit., 433.

The patient, who was but eighteen years of age, had for several years been the victim of constitutional debility that disqualified her for indulging in any considerable amount of exercise.

This debility, however, was not, as she asserted, sufficient to account for the indisposition frequently evinced of making any exertion. At these times, whenever she ascended the stairs, or even attempted to walk across the room, she complained earnestly of severe pain in the left ovarian region, which extended down the left and sometimes even the right leg. She was at all times excessively low-spirited, and usually indulged during the day in several *quiet* crying spells. When her paroxysms of weeping were unusually violent (presenting more of the hysterical character) the cardiac nerves seemed to suffer, as evidenced by attack of palpitation with deranged rhythm. These paroxysms were attended by greatly increased pain in the ovarian region, and this pain she regarded as the cause of all her unpleasant symptoms. The fact that this part was exceedingly sensitive to pressure, while the right side was insensible to ordinary impressions, was to her and her friends additional proof that her nervous condition was an effect and not a cause of this local irritation. As counter-irritation and the usual tonic influences indicated in such a case seemed to afford but little or no relief, her physician advised electrization, and invited us to treat the patient. A gentle faradic current, applied with the hand as an electrode over the left ovarian region, caused greater pain than pressure alone, and immediately excited an attack of crying.

After she had been treated several times, and had become familiar with the operation, it was interesting to notice the fact that if her attention was engaged in earnest conversation during an application, the current excited in her no manifestation of pain.

If her mind was recalled to the operation on hand, the part *suddenly and unaccountably* became as sensitive as ever. The patient continued treatment two months, and received twenty general applications.

Uninterrupted improvement followed our endeavors. She gradually gained in strength and spirits. Her paroxysms of weeping became less and less frequent until she was comparatively free from them.

As she improved in these respects, the irritation in the left ovarian region of which she complained gradually left her, until she was annoyed by it no more.

There is one symptom occasionally accompanying hysterical conditions, and which is invariably associated with hyperæsthesia of the skin, that we do not find given in the descriptions of this disease. We refer to an increased redness of different portions of the surface of the body. This complication is annoying under any circumstances, but more especially so when an exposed part of the body, as the nose, is the seat of the increased color.

Hysteria caused by grief—Paroxysms of weeping—Unnatural redness of skin of arms and nose—Recovery under general faradization.

CASE 19.—The patient—a young lady, 23 years of age—had lost her sister four months previously, and from that affliction she dated all her symptoms. Before this affliction she had enjoyed almost perfect health and was remarkably buoyant in her disposition. During her sister's illness she had been her constant attendant, and had become reduced considerably in strength.

After the burial all strength and energy seemed to leave her: the appetite was lost, and for several days and nights she wept continually, neither eating nor sleeping.

Recovering in a measure from this prostration, she tried change of scene, hoping thus to dissipate her miserably nervous condition. She derived but little benefit, and when we saw her her condition was indeed pitiable. In relating how miserably she felt; how little inclination she had to meet her dearest friends; how the sound of music distressed her; and what terrible choking sensations she constantly experienced, the tears flowed thick and fast. The menstrual function was performed with perfect regularity; the amount of blood lost was not excessive, and was accompanied by no pain. All her organs seemed to be in a healthy condition. The patient called especial attention to this increased redness of skin, of which mention has been made. It was particularly marked upon the arms and nose, and when she felt more hysterical than usual the redness increased, and was accompanied by an annoying sensation of heat. This impairment of her personal appearance weighed upon her mind constantly and seemed to greatly increase her distress. Two applications of a mild faradic current so benefited her that for thirty-six hours the constriction of the throat ceased to annoy her. As she continued receiving the influence of electrization, and the current was increased, she improved rapidly in her general condition, and after eight applications the heightened color which so annoyed her was entirely dissipated, and with it nearly every other unpleasant symptom, so that she again entered society and seemed to enjoy life as well as ever.

Hysteria—Violent paroxysms of weeping—Great mental depression verging toward insanity—Impairment of memory—Neuralgia, anæsthesia, and dyspepsia—Entire recovery under general faradization.

CASE 20.—In December, 1867, Dr. F. D. Weisse, of this city, consulted us regarding the condition of one of his lady patients, who was suffering from an aggravated form of hysteria.

Notwithstanding his best endeavors, the case seemed to resist obstinately every form of medication, until finally he resolved to place her under the tonic influence of general electrization. The patient was a married lady, aged about thirty-five. Although never very strong, she had until of late years enjoyed a fair degree of health, and had given birth to several children; her whole appearance now indicated excessive exhaustion, but there was no evidence of any serious organic difficulty. Her symptoms were: intense mental depression, with paroxysms of violent crying; impairment of memory; loss of appetite; indigestion, attended with an excessively annoying flatulence; neuralgia of the head; anæsthesia, that shifted from place to place.

At times the depression and the fits of weeping which so frequently overcame her so closely assumed the form of insanity that her nearest relatives had seriously considered the question whether it would not be better for her to be confined in an asylum. It was quite common for her, without any appreciable cause, to start suddenly from her chair, scream, and partially faint. She would sometimes weep for hours, and yet be unable to assign any specific cause for her distress.

On the occasion of her first visit to us she became excessively nervous, and manifested an almost childish fear of the operation. When she was ready for treatment her nervous anxiety had so much increased that we thought it best to *pretend* merely to make an application. Her feet were placed upon the copper plate to which the negative pole was attached, the instrument set in operation; and our hand as an electrode applied to the back of the neck. No current passed, however, as the positive electrode had been disconnected from the instrument. As soon as the hand of the operator was applied to her, she declared that she felt the electricity tingling through her whole system; but further remarked, that it was not so terrible as she had imagined. We were able at the next visit to pass a mild current down the spine and over her liver, stomach, and spleen. Her stomach was so sensitive that even this gentle application caused pain over that organ, together with a decided feeling of faintness. At the third visit her condition manifested marked improvement.

Her appetite had improved; she was less despondent and nervous; her strength had increased, and her sleep had been unusually quiet and refreshing.

A very decided feature of her changed condition was the fact that a current of twice the intensity of that previously given was now borne without the slightest discomfort.

The fourth application ameliorated somewhat the distressing flatulence from which she suffered, and after the fifth it ceased to annoy her to any very considerable extent, while her neuralgic pains were entirely dissipated. It may be stated that an application to the eyes at this time resulted in an overpowering drowsiness, which lasted twenty-four hours. On January 8th, 1868, after having received but eight applications, and having been under treatment but about three weeks, we summed up the results as follows:—

Removal of mental depression.

Removal of paroxysms of weeping.

Strengthened memory.

Almost completely relieved of flatulence and indigestion.
Neuralgia dissipated.
Anæsthesia completely relieved.
Increase of strength.

This patient (in whose case the results of treatment were so gratifying) was not suffering, as we were informed by her physician, from any decided derangement of the sexual apparatus.

In some cases where the diagnosis hysteria seems justifiable, no decided benefit results.

Debility—Spinal irritation—Constant headache on the left side—No marked improvement under general faradization.

CASE 21.—Mrs. M., aged 27, was referred to us September 11, 1867, by Dr. Joseph Kammerer. For seven years she had been more or less an invalid; was first attacked with hysterical symptoms after confinement. Since the birth of her last child, one year before, had been very feeble. Several years previous she had suffered from *prolapsus uteri*. Her symptoms at the time she came under our care were constant headache on the left side, tenderness of the upper cervical vertebræ on pressure, occasional attacks of epistaxis and debility.

Treatment by general faradization was employed eighteen times, during a period of three months, and with only slight temporary improvement.

Galvanization of the spine and sympathetic, that were indicated in the case, were not tried.

The spinal irritation was sufficiently marked to classify the disease under that head.

CHAPTER XX.

CHLOROSIS AND ANÆMIA.

THE view at present accepted is that chlorosis and anæmia are not identical, as was formerly held, but that they are two distinct affections; that chlorosis is a disease of the nervous system, and anæmia a disease of the blood. They may, however, be associated—the anæmia being the result of the chlorosis.

Both may be accompanied by a wide variety of symptoms of debility, which frequently mask the general condition, and perhaps deceive the observer.

The change of view concerning the nature of chlorosis is the result of the labors of Becquerel, Valleix, and other French authorities.

Prof. T. G. Thomas* thus contrasts the two affections:—

Anæmia	*Chlorosis*
"Is merely impoverishment of the blood from want of nourishment, from some drain upon the system, or from some poison in the blood.	Is a disease of the nervous system, and may occur with or without the production of its most common symptom, anæmia.
Can usually be accounted for by discovery of some special cause.	Cannot usually be accounted for by discovery of special causes.
Occurs at all periods of life, to men, women, and children.	Occurs in true type only to girls about time of puberty.
Is readily curable by removal of cause, good diet, and administration of iron.	Is affected favorably only by remedies which act upon the nervous system, as alteratives and tonics.
Is always characterized by impoverishment of blood.	Sometimes exists without impoverishment of the blood.
Produces puffy and pale appearance.	Produces a light green color.
Does not produce sadness or great nervous disquietude.	Produces sadness and nervous disquietude.

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* Diseases of Women, second edition, p. 626.

Is unaccompanied by visceral neuralgia.	Is constantly accompanied by visceral neuralgia
Fibrin diminished in blood.	Fibrin increased in blood.
No special affection of solar plexus of nerves.	Pain, uneasiness, or distress, commonly referred to solar plexus.
Iron always does good.	Iron often increases discomfort.
Symptoms of ovulation will be noticed without menstruation.	Neither symptoms of ovulation nor menstruation will be observed.
The cause of the disease being removed, patient will rapidly improve.	If supposed cause be removed, patient will often improve, but slowly."

Concerning the causation of chlorosis, there seems to be good reason for accepting the theory of Prof. Thomas,* that "this process of development, which we term puberty, is under the control of the ganglionic or sympathetic system of nerves, which at that time must necessarily be in a condition of excessive susceptibility. It is probable that in that state of exaltation it is, in the female, often affected by a functional derangement, which creates the collection of symptoms to which we give the name chlorosis." The pathology might also be supposed to consist in simple exhaustion of the nervous force.

Treatment.—In their relation to electro-therapeutics, both diseases are to be treated on substantially the same general principles, that is, by general electrization; except that in chlorosis more attention should be given to galvanization of the sympathetic.

In anæmia, our results have been obtained mainly by general faradization.

Prognosis.—Cases of anæmia that are not dependent on incurable organic lesion, or persistently maintained by bad moral or hygienic influences, are sure to be benefited. Our record of anæmia is as follows:—

Whole number treated	14
Recovered	3
Approximately recovered	3
Decidedly benefited	4
Slightly "	2
Not "	1
Unknown	1

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* Op. cit, p. 622.

Anæmia caused by profuse hemorrhage from the bowels, with neuralgia—Rapid and permanent improvement under general faradization.

CASE 22.—Nov. 11, 1868, a physician, 52 years of age, requested us to treat him for a profuse and mysterious hemorrhage from the bowels, which was continually draining his blood to the extent of several ounces daily, with proportionate diminution of strength.

Careful study of the case by his attending physician, and rectal examination by a distinguished surgeon, had failed to determine either the nature or the locality of the morbid process of which the hemorrhage was a symptom.

At the time we first saw the Doctor he was exceedingly anæmic, face, lips, and hands pale and bloodless, and every day he was growing worse under the repeated sanguineous discharges from the bowels. Anæmic neuralgia, which Romberg has defined as "the prayer of the nerve for healthy blood," was felt in both upper and lower limbs.

On account of his increasing debility, he had been compelled to suspend his practice and to confine himself to the house.

The Doctor sent for us in order to see whether it might not be possible to check the discharge by localizing the current in or through the bowels. This experiment we refused to make, since we knew nothing of the morbid process, and had neither experience nor any satisfactory theory to guide us in undertaking any such experiment.

The only indication was to *combat the anæmia and debility* that *had resulted from the loss of blood*, in the possible hope that the improvement thereby obtained *might react curatively on the mysterious lesion in the bowels.*

We therefore began the employment of general faradization, without special reference to the bowels or to the viscera, but at the same time not neglecting them.

Improvement followed the first application. After the fourth application the neuralgia disappeared, and the appearance of the patient began to visibly improve. In three weeks he had gained markedly, not only in his appearance, but in his muscular strength, and he began to resume the practice of his profession. During all this time the discharge of blood from the bowels had been gradually lessening, and at the end of six weeks it was reduced to a minimum; the patient had recovered his normal color and appearance, and was able to attend to his ordinary duties.

With reference to this case, it is proper to state (1.) that the patient was taking quinine when we first visited him, and continued its use for a while during the course of treatment by general faradization. And yet, since he was growing rather worse than better in spite of the quinine, and as improvement began at once after the use of electrization, and rapidly and steadily progressed, it is fair to believe that the ultimate recovery of the patient was nearly, if not entirely, due to the tonic effect of the electrization. (2.) Prior to this time, the patient had experienced similar, though not alarming attacks of hemorrhage from the bowels; and since that time, also, the symptom has several times returned, but not with such force or persistence as to demand electrical treatment.

Anæmia associated with Addison's disease—Dark skin, deficient secretions, paralysis of left arm, loss of sexual power—Very great improvement under general faradization—Slight further improvement under galvanization of sympathetic.

CASE 23.—In regard to the pathology of Addison's Disease, our knowledge is very incomplete. In a large proportion of cases the bronzing of the skin, and the peculiar cachectic condition of the affection, are preceded by organic lesion of the supra-renal capsules.

Cases are not wanting, however, in which *post-mortem* examinations have revealed no anatomical lesion of the capsules, notwithstanding the previous existence of the most marked and severe characteristics of Addison's Disease.

Dr. Wilkes states, "That after some years' attention to the subject, I repeat, with much confidence, that the disease of the capsules in Morbus Addisonii is uniform and peculiar. In all the examples which we have now in our museum, amounting to thirty-three, the disease is of the same nature in all." *

Of 196 cases reported by Dr. Greenhow, the supra-renal capsules were found to have undergone the characteristic morbid change in 127.†

In consideration, therefore, of these facts, it is extremely probable that certain organic changes in the capsule of the kidney, and the peculiar symptoms of the disease under consideration, are directly related to each other as cause and effect. If the affection be recognized before the bronzing of the skin has taken place, it may possibly be arrested.

Unfortunately, however, it is, as a rule, impossible to diagnose the disease before the discoloration of the skin commences, when it is generally acknowledged to be incurable.

In regard to this bronzed discoloration of the skin, microscopical examinations, by Dalton and others, have demonstrated that it is due to pigmentary granules in the rete mucosum, similar to those in the skin of the negro.

The patient, a man aged 45, was referred to us by Dr. H. H. Gregory, of Harlem, and the diagnosis of disease of the supra-renal capsules was confirmed by Prof. Austin Flint.

Until November, 1867, the patient enjoyed perfect health.

About this time he began to observe slight symptoms of exhaustion. Soon his appetite failed him. He became anæmic, and suffered from excessive fatigue after the slightest exertion.

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* Guy's Hospital Reports, vol. xi., 1865. Quoted from Aitken's Practice of Medicine, vol. ii., pp. 113.

† Clymer in Aitken's Practice of Medicine, vol. ii., p. 110.

He was confined to his bed during the month of January, when he first observed some slight discoloration of his face and hands.

During the succeeding months, until August, 1868, his general health seemed to improve somewhat, so that he was enabled to engage in moderate labor. At this time he suddenly relapsed into a state of utter exhaustion. His skin became several shades darker, and his general appearance was that of an ordinary mulatto.

His bowels became distressingly constipated. Sleep was fitful and unrefreshing. His mouth and throat were excessively dry and parched; indeed, the function of the secretory organs generally was markedly impaired.

The skin was shrivelled and dry. The finger-nails were brittle, breaking on the application of a very slight force. The left arm was stiff and almost powerless. It could not be bent beyond a right angle, nor lifted more than a few inches from the side. Lastly, the sexual power and desire were entirely lost.

All of these symptoms persisted, with but slight variation, notwithstanding an uninterrupted tonic treatment, until June, 1869, when the case fell under our observation. As the most prominent and distressing symptom of which the patient complained was the excessive debility that unfitted him for the slightest exertion, the results of treatment by general electrization illustrate more forcibly than in most other instances its remarkable constitutional tonic power. A general application of the faradic current revealed not only a profound anæsthetic condition of the whole body, but also an unusual general impairment of the electro-muscular contractility. By placing the negative electrode at the pit of the stomach, and the positive on the neck, a little above the seventh cervical vertebra, distressing nausea was invariably produced.

The patient began to amend from the first day of treatment, and, after having received thirty general applications of the faradic current, his condition at that date may be thus summed up:—

1st. He had long been completely cured of his constipation.

2d. Sleep was perfectly sound and refreshing.

3d. The dry and parched condition of his mouth and throat was entirely relieved, and all the secretions of the body had increased in quantity and quality.

4th. His finger-nails were restored to their usual elasticity.

5th. He had approximately recovered the use of his arm. This improvement was manifest after the third application.

6th. The sexual organs had been very decidedly strengthened.

7th. Above all, his strength and power of endurance had progressed with the above changes. At first he was barely able to crawl a single block; he could afterwards walk a couple of miles without suffering unpleasant fatigue, and could readily engage in any light labor.

8th. In regard to the bronzing of the skin, the change was not, as yet, very marked. The discoloration seemed to be a shade lighter, and had sensibly receded on the sides of the fingers and hands.

We have referred to the nausea excited by the electric current. In view of certain theories that have been advanced concerning Addison's Disease, this fact is of considerable interest.

The semi-lunar ganglion and solar plexus, and also the pneumogastric and phrenic nerves, supply nervous filaments to the capsules.

In consideration of this fact, Dr. Habershon and others are of the "opinion that the more fully the disease is known the more completely will it be traced to the sympathetic nerve." The unusual action of even a mild current on that nerve, in producing nausea, tends to strengthen this conclusion.

This annoying symptom rapidly became less marked as the patient gained strength under the influence of electrization, and a most powerful current could soon be applied without causing inconvenience.

The patient was subsequently treated by galvanization of the sympathetic, with some further, though not marked, improvement.

Chlorosis, with hysterical symptoms—Great mental depression—Amenorrhœa—Temporary relief by general electrization.

CASE 24.—Mrs. S., a young married lady from Cincinnati, was treated by us, at the request of Prof. T. G. Thomas, for symptoms partly chlorotic and partly hysterical. The patient was of the nervous diathesis and had never been strong. The symptom of amenorrhœa of which she had latterly complained had been treated locally by skilful gynecologists for one year without satisfactory results. At the time we first saw the patient, February 12th, 1869, she was excessively nervous and timid; morbidly apprehensive, suspicious, and exceedingly sensitive. The utmost caution was needed in all conversation and dealings with her. Scarcely any function was well performed. Appetite was feeble and capricious, sleep uncertain and inconstant. Her physical and mental symptoms combined made her a most trying patient.

We employed general faradization, and also internal tonics were administered by Prof. Thomas. As is not unfrequently the case with patients of this class, she was very susceptible to the sensation produced by the passage of the current; the whole body was in a condition of hyperæsthesia. The contractions produced in the muscles of the leg, when the feet were placed on the pole, were so annoying to her that it was found necessary to vary the application.

At first, under combined external and internal treatment, the patient seemed to improve. She became calmer, more hopeful, and was rather less exacting and apprehensive. The apparent improvement was not retained, either on account of some unpleasant tidings that came to her during the treatment, or because the applications were too severe or too protracted; the patient in the latter part of March began to complain of sick headache of a vertiginous character, such as she had experienced in former times. Meantime the menstrual flow was not much increased, although in addition to the general treatment the current was localized through the uterus just before the time for the menses.

The patient, fearful lest the electricity might be the cause of her headaches, was unwilling to continue the treatment. Other treatment was also shortly after abandoned.

We were informed that after her return to the West she improved very decidedly in her general condition. Such after-improvement has been observed by us in several striking instances, when during the course of the treatment but little benefit was appreciated.

CHAPTER XXI.

INSOMNIA.

INSOMNIA is a symptom which, with greater or less uniformity and severity, accompanies nearly all forms of disease. It results from affections not only of the brain, but also of the spinal cord, and of the prominent organs, as the stomach, the heart, the liver, and the genital apparatus. That persistent wakefulness is a premonitory symptom in insanity is well known. It is not so generally known that it is frequently premonitory of diseases of the spinal cord; it is one of the symptoms first experienced by patients affected with locomotor ataxy, spinal irritation, and myelitis. Patients afflicted with dyspepsia, hypochondria, neuralgia, anæmia, neurasthenia, as all physicians know, complain in a large number of cases of insomnia as one of their most distressing symptoms. A noteworthy fact concerning insomnia is, that it is a more constant symptom in the earlier stages of disease of the brain and spinal cord than in the latter stages of incurable paralysis. It is one of the most annoying features of the decline of old age. The very great prevalence of insomnia, and the insufficiency of the historic method of treating it by opiates and other anodynes, are shown by the extraordinary rapidity with which bromide of potassium and hydrate of chloral have become popularized.

Insomnia is a symptom of such an indefinite variety and complexity of pathological conditions that it is manifestly impossible to treat it with anything like uniform success by any one conceivable form of medication; but of all the remedies that have yet been tried there is, we believe, no one which permanently relieves the symptoms in so large a proportion of cases as electrization. The effects of electrization on the sleep, whether used in the form of general electrization, galvanization of the head and cervical sympathetic, are both temporary and permanent. The *temporary* relief that appears the night or two following an application, though usually far less potent than those of bromide of potassium and hydrate of chloral, are yet very decided ; but it is for the *permanent* relief that electrization is chiefly indicated in this symptom. This comes gradually, slowly, and as a result of the improvement of the morbid condition on which the insomnia depends.

As was stated on page 227, improvement in sleep is one of the earliest effects for which we look during a course of treatment by general electrization. In a wide range of diseases sleep, to a certain extent and with exceptions, may be regarded as a thermometer of health. When all other bodily functions are well performed, the sleep is usually sound, calm, and refreshing ; when it becomes painfully and persistently disturbed by dreams, or is long absent, we may suspect actual or approaching disease.

Temporary loss of sleep, that comes from temporary anxiety or from neuralgia or other pain, is usually relieved with the removal of the cause, and only demands special medical treatment when it is long continued.

The *treatment* of insomnia is really the treatment of all the diseases on which it depends. For those cases where simple wakefulness exists, unaccompanied by any other symptom of recognizable disease, we may use either galvanization of the sympathetic or in the head, or faradization of the head and spine, or, better than all, general faradization, for somnolence is a result of all these methods of electrization. It is not even necessary to make the applications to the head, the sympathetic, or even to the spine, in order to produce sleep. Simple peripheral galvanization or faradization will produce this result, and in some cases to a very marked degree. This must, we suppose, be explained by reflex action. In case of rheumatism of the hip-joint, which we once treated by galvanization through the joint, the soporific effect on the patient was so marked that he fell into a profound slumber before we had time to leave the house, in less than ten minutes after the application was over. In another case of infantile paralysis the mother reported that the child slept soundly for two hours or more after each sitting, although only the limbs were galvanized.

For the rationale of the effect of electrization in the production of sleep we may refer to the chapter on galvanization of the Sympathetic.

To detail cases of insomnia treated by electrization would seem to be superfluous, since a majority of the cases of nervous diseases recorded throughout the book were more or less complicated with disturbance of sleep, and in nearly all the successful results improvement in sleep was an early and marked feature.

Of 18 cases that we have registered under insomnia—

7 recovered entirely.
2 " approximately.
4 were decidedly benefited.
2 " slightly benefited.
1 not benefited.
2 results not known.

Persistent insomnia after child-birth—An application of the faradic current to the head and spine is followed by sleep of several hours.

CASE 25.—Mrs. A., aged 30, of a highly nervous organization, gave birth to her first child after a labor of 16 hours. So great was the disorder of her nervous system, that for 5 days and nights she was unable to close her eyes in sleep. Her condition was most distressing, and resisted all efforts in the way of medication.

It was agreed that a mild application of the faradic current should be applied to the head and down the spine. The result was most decided and gratifying, since a sleep of several hours, deep and refreshing, immediately followed. It is proper to say that subsequent applications did not have the same decided effect, although they evidently strengthened the nervous system of the patient and greatly aided in dissipating the condition of insomnia.

CHAPTER XXII.

NEURALGIA.

When, in any disease, the pain follows the course of any particular or prominent nerve-branch, it receives the name neuralgia. The name has also been extended to include pain in the head and spinal cord. The pains of the affection are usually quite sudden in their onset, and are of a lancinating, stabbing, darting, or burning character. They are more or less intermittent, and are not ordinarily accompanied by any constitutional febrile disturbance.

Neuralgia has usually been classified according to the locality of the pain, and corresponding special names are given to it. Thus we have facial, brachial, intercostal, and abdominal neuralgia; gastralgia, sciatica, &c. This method of classification, though convenient, and to a certain extent indispensable, is yet hardly satisfactory. It grew up in the times of professional ignorance, and therefore gives no idea of the special nature of the affection, and can be no guide in the prognosis or therapeutics. The method of classification of the neuralgias that we adopt is ***based on the local or general condition in which they take their origin.***

All conceivable forms and phases of this affection may be included under one or the other of these four grand divisions :—

1st. *Constitutional Neuralgias.*—Those which arise from constitutional conditions : anæmia, neurasthenia (nervous exhaustion), poisoning by minerals and various diseases, as syphilis, mercury, lead, rheumatism, gout.

2d. *Central Neuralgias.*—Those which arise from disease of the central nervous system : irritation, inflammation, congestion of the brain and spinal cord, also tumors, pressure of foreign substances, &c.

3d. *Peripheral Neuralgias.*—Those which arise from local diseases of, injury to, or pressure on, the nerve: neuritis, neuroma, aneurisms, wounds, bruises, &c.

4th. *Reflex Neuralgias.*—Those which arise from reflex action. This class embraces a large number of neuralgias that attack all portions of the body.

Complicated cases occur that may properly belong to two or more of these divisions. A patient afflicted with anæmia may suffer from neuralgia that may be aggravated by neuritis, or by a wound or bruise. A curable case of neuralgia of malarial origin may be rendered incurable by the supervention of organic disease of the brain or spinal cord.

Of these four varieties, the first two are the more, and the last two the least numerous. Probably, as our diagnosis becomes more and more refined and exact, it will be found that a very large proportion of our neuralgias are of *central* origin.

Electro-diagnosis in neuralgia discovers the painful spots that are detected by pressure in the course of the affected nerve, and may also discover sensitive points on the spine, or the head, or on the cervical sympathetic, that might, perhaps, have otherwise escaped observation. Electric examination assists us in determining the very important point whether the disease is or is not of central origin. In no other disease is the diagnosis of the seat of the disease so important.

Treatment.—Before attempting the electric treatment of neuralgia, we should endeavor to diagnose its general character, in order to decide upon the method to be employed. In doubtful cases it is necessary to try in succession central, peripheral, and general treatment.

The treatment of the different varieties of neuralgia is the best test of skill in electro-therapeutics. There is no disease or symptom in which the results of treatment in different cases so closely depend on the nature and strength of the current used, and the method and frequency of the applications.

Cases that injudicious treatment might aggravate may, by the exercise of the skill and caution that experience teach, be rapidly cured.

The success achieved by electrization in the treatment of neuralgia has been brilliant and remarkable, and would be sufficient of itself to entitle it to a prominent and indispensable position among modern remedies. What is more remarkable still, is that this success has been achieved by very diverse methods of applications, and with imperfect, indifferent, or incorrect diagnoses. All forms of electricity—statical, galvanic, and faradic—in all the different methods and phases of electrization, general and localized, centrally and peripherally, by currents, stable, labile, continuous, interrupted, uniform, and increasing.

The pain is frequently relieved in the midst of the application; but in such cases it usually returns in the course of a few hours, and sometimes with heightened intensity. Some cases of a peripheral character are permanently dispelled by one or two applications.

Electricity is applied for neuralgia in the following forms:—

General faradization and galvanization, and galvano-faradization.

Localized faradization or galvanization, central or peripheral, or both combined.

Galvanization of the sympathetic.

Electric brush.

Electric moxa.

Statical electricity.

Electric bands and disks.

The magnet.

The question which of these methods is to be preferred is to be answered by a study of the causation, symptoms, and pathology of each case.

It is indispensable, therefore, in the scientific treatment of neuralgia, at the outset to determine, so far as possible, the nature of the affection, whether constitutional, central, peripheral, or reflex.

Many of the failures and disappointments with the use of electricity in neuralgia have been due to the mistake of treating *constitutional disease locally, and the central varieties peripherically.* Failures there have been, and must be, so long as there exist incurable pathological conditions giving rise to neuralgic pains; but the cases of neuralgia, taking them as they run, without reference to their pathology or causation, that remain obstinately rebellious to electrization, are a very small minority, and are chiefly found among those depending on incurable disease of the brain or spinal cord.

There is one difficulty in the treatment of neuralgia by electrization, and that is that, on account of the intensity of the pain, patients are sometimes unwilling to give the treatment a fair trial. This difficulty is further increased by the fact that, during or after the first two or three applications, the pain may be *temporarily aggravated*, especially if the sittings have been long, or with currents of too great strength. For this reason the initial applications should be made with caution, and the operator should not yield to the temptation to renew them too frequently. Once a day, or every other day, is about as often as applications can be made with benefit.

As before remarked, the methods of applying electricity must be studiously adapted and varied to each case, ever *keeping in mind that all methods of using electricity have been successful in this disease, and that no one method is uniformly successful even in the same variety.*

Besides the central and general electrization, which is to be conducted on general principles, in order to affect the seat of the *disease*, all the varieties of neuralgia may demand more or less treatment in the seat of the *pain*. For this purpose we may use either faradic or galvanic currents. Although the faradic achieves excellent results, yet some of the most striking results have been obtained by the galvanic. It sometimes relieves the pain when the faradic only aggravates it.* After the faradic current has been tried a few times without effect, we should never abandon the case without resorting to the galvanic, or the two currents may be used alternately. As a rule, the applications should be short and made with a mild current; but this rule has marked exceptions. There appears to be no special law in regard to the direction of the current. Either the positive or the negative pole may be placed over the painful points, while the other pole is applied near or on the nerve centre (see p. 165). Thus, in neuralgia of the arms, one pole may be placed at the cilio-spinal centre, and in neuralgia of the legs, on the lumbar vertebræ, and the other on the affected nerve (spinal-cord-nerve current.)

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* The statement of Niemeyer, that the faradic current never succeeds in neuralgia after the galvanic fails, is not entirely true. We have seen two or three cases where relief was obtained by faradization, after galvanization had at least apparently failed.

The *electric moxa* (see p. 160) is sometimes more rapidly efficacious in neuralgia than any other method of treatment. It is, however, a very painful procedure, and many patients will not bear it.

It seems to act partly as a counter-irritant. Meyer* very strongly advocates the use of electric moxa in neuralgia, and sustains his position by a number of cases.

Prognosis.—The prognosis in neuralgia, under electrical treatment, manifestly depends on the pathology. If the case is incurable, the pain will not be permanently relieved. Cases of a central origin do not necessarily offer a worse prognosis than those of a peripheral origin. More depends on the nature than on the seat of the lesion. Constitutional cases, where the poison is not definitely localized, almost invariably yield to general faradization. Simple facial neuralgia recovers speedily under judicious electrical treatment, while epileptiform neuralgia yielded only in the minority of cases.

Take the cases as they arise, without reference to their pathology or duration, neuralgia offers a very favorable prognosis. The majority of cases will be cured or permanently improved. Of 70 cases of neuralgia of all kinds that we have treated, 30 recovered, 10 approximately recovered, 9 were decidedly benefited, 7 were slightly benefited, 5 were not benefited; in 3 cases the symptoms were aggravated, and in 5 cases the results were not known.

CONSTITUTIONAL NEURALGIA.

The constitutional conditions that are most frequently the causes of this form of neuralgia are unquestionably anæmia and neurasthenia, or what is commonly known as nervous exhaustion, inasmuch as these conditions are themselves very frequently the results of poisoning of the system by mercury, lead, opium, alcohol, malaria, rheumatism, gout, etc. It is in every way probable that mineral poisons, like syphilis, etc., may produce lesions of the nerve-centre, and thus give rise to central neuralgia.

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* Op. cit., p. 308, et seq.

Treatment.—Constitutional neuralgia calls for general electrization.

The *prognosis* for the majority of cases is favorable. Relapses sometimes occur, especially in cases dependent on mineral or malarial poisons.

Paroxysmal attacks of a most distressing general neuralgia, associated with menorrhagia and anæsthesia, treated by general faradization—Recovery.

CASE 26.—A lady whom we treated presented symptoms typically descriptive of the above condition. Her age was about 30; married, but childless. She had suffered from several miscarriages, and had been treated for a long time for ulceration of the neck of the uterus, that finally yielded to local applications. Up to her twenty-fifth year she had enjoyed a good degree of health; but after her first miscarriage she began to suffer from prolonged menstruation, attended with an excessive flow. This condition had existed but a few months when the patient began to experience certain wandering pains over the body, that became more marked at each return of the catamenia, until the paroxysms assumed a most distressing character. They were usually ushered in by tenderness and a sensation of oppression in the epigastric region. Throughout the whole attack the most acute pain would be felt over the stomach, and was attended by vomiting. Most of the body was, however, to a greater or less extent, affected by the disorder. The head became tender to the touch, the eyes intolerant to light, and the tongue and mucous surfaces of the cheek would be affected by a very annoying sensation of numbness. Several times a year she was prostrated by symptoms that were very sudden in their onset, and exceedingly alarming in character. The pulse, almost without warning, would fall to 40 or 45 in the minute, and become so feeble as to be hardly perceptible. The power of articulation left her, the anæsthesia of the mouth and tongue became complete, and her face assumed a deadly color and coldness. These attacks lasted from twenty minutes to half an hour, and were treated by the free use of brandy and carb. of ammonia. An application of general faradization, given one evening during one of her periodical monthly paroxysms, so relieved the distress that a quiet night was the result. It may be here stated that it was impossible for the patient to take opium in any form with benefit. Exceedingly small doses caused sleeplessness and the most intense excitement. Invariably after this we found that a similar application would greatly alleviate the pain. The main idea, however, was to strengthen the general system, and so prevent these attacks. For this purpose, on every other day she was treated thoroughly by general electrization, and it was not long before its good effects were manifest. In the course of a few weeks her powers of endurance had increased considerably; and when the menses appeared they were of shorter duration, and attended with a much less loss of blood than before. The neuralgic pains were incomparably less severe; and she rallied to her usual condition immediately. After remaining under treatment several months she was discharged as cured. Two years have elapsed since treatment was discontinued, but she has never suffered since from those occasional attacks of which mention was made. Her menses continue regular and normal; and it is only after great provocation that she ever experiences paroxysms like those of former days.

Formerly, according to our older authorities, neuralgia of a malarial origin was not unfrequent; but of later years, as civilization has advanced and our system of drainage improved, especially in our Northern States, this cause has played a much less important part in the development of neuralgic pains.

When one is attacked with a persistent neuralgia that occurs in paroxysms, quotidian or tertian, and finally yields only to quinine, or quinine and iron, we naturally conclude (even though the district to appearances be not a malarious one) that a malarial influence is at the root of the difficulty. Neuralgias that follow mere cold and damp are of every-day occurrence, and are speedily dissipated by confinement within doors, or by some simple local application. No specific poison has entered the system, and no specific treatment is needed.

The influences of malaria seem to be specially directed towards the nervous system, and thereby may generate a large variety of disorders. Neuralgia is undoubtedly at times one of its most distressing manifestations.

As malaria exercises a remarkably depressing effect upon the cerebro-spinal and sympathetic systems, we can readily account for the severity of the neuralgic pains to which it gives rise.

Intercostal neuralgia of a malarial origin—Recovery under general faradization.

CASE 27.—A young man, who had been exposed to the hardships and dangers of a frontier life, was suffering from distressing pains that were confined mainly to the thoracic region on either side. Several months before we saw him, he was prostrated by an attack of intermittent fever that recurred several times after being apparently subdued.

One of the paroxysms was followed by what his attendant called "*brow ague*"—a term not unfamiliar some years ago to the residents of malarial districts.

It was characterized by sharp shooting pains all over the head and face, affecting, however, especially the forehead and eyes. The neuralgic symptoms soon abandoned these parts, but in a few days manifested themselves by an unusually severe paroxysm in the chest and side. For a number of months before he fell under our notice, attacks of intercostal neuralgia occurred at intervals of two or three days.

The patient experienced no distinct chills or marked febrile excitement, but the neuralgia was almost invariably ushered in by a creeping sensation of cold down the back and limbs. The exciting cause was undoubtedly a malarial poison. The diagnosis of neuralgia was unmistakably confirmed by the presence of that almost pathognomonic symptom, namely, pain on pressure over the spinous process of one of the last dorsal vertebræ. A gradual improvement took place under frequent general applications of the faradic current. Quinine was administered at the same time, so that we cannot state in positive terms the exact amount of credit due electrization. It must be remembered, however, that quinine had been taken for some time previously, and was followed by no very marked results. The first application, administered during a paroxysm of ordinary severity, was followed by a very grateful amelioration of the pain, and in all subsequent attacks the same result followed.

Ten applications served to break the periodicity of the attacks, and to place him on a plane so little below the normal, that it could be fairly said of him that he was approximately cured.

Intercostal neuralgia, resulting from exposure to camp life—Spinal Irritation—Debility—Rapid improvement and recovery under general faradization.

CASE 28.—L. C., aged 28, served in a Nevada regiment for three years during the war. After his discharge, in the fall of 1865, he was taken with acute articular rheumatism, which confined him to a hospital during the whole winter. The spring found him much better, and in a few months there seemed to be no vestige of the rheumatism remaining. His health remained delicate. In July, 1866, he was taken with severe pains in the back and side. He was treated by localized faradization a few times, but with no appreciable benefit. The neuralgia increased in severity, locating itself between the ribs. In January, 1867, he applied to us for treatment. He was then extremely weak, and presented a remarkably anæmic appearance. There was very great hyperæsthesia over the peripheral expansion of the affected nerves. Slight irritation by the finger-nail, or moderate pressure by the hand, was sufficient to cause considerable pain. On account of this extreme sensibility he was obliged to substitute for the coarse red flannel which he had been accustomed to wear, an undershirt of finer texture. Pressure made upon the first spinous processes of the dorsal vertebræ caused no uneasiness, but when the sixth and seventh processes were firmly pressed, the patient loudly complained. We gave him a general application, as is our custom in such cases The whole system was brought powerfully under the influence of the faradic current. The application at once relieved him, and in three days he was directed to come again. During that time he suffered much less than usual; his appetite had improved, and for the first thirty-six hours he was much invigorated. He visited us for one month, during which time he received ten general applications. The improvement was uninterrupted from the beginning.

After the fourth application he suffered no more from the neuralgia. The color returned to his cheek; his appetite became more vigorous from week to week, and, when he discontinued treatment, we regarded him as comparatively well.

This case called for a powerful constitutional tonic. Hardships in the army and previous disease had reduced his stock of vitality to such a degree that our ordinary internal tonics failed to produce their accustomed results. His nervous system had been so shaken, and all his functions so disturbed, that he. could not assimilate the iron and bitters that were so much needed. It is in such cases that general electrization achieves most satisfactory results.

Neuralgia of eighteen months' standing, affecting the head, thorax, and left arm, and following a severe attack of intermittent fever—Treatment by general faradization—Approximate recovery in seven weeks—Increase of appetite and weight—Subsequent relapse.

CASE 29.—Mrs. W., a married lady, 27 years of age, reported that eighteen months previously she was prostrated with an attack of intermittent fever that left her in a very weak, anæmic, and neuralgic condition, from which no combination of internal tonics seemed to enable her to rally. Her symptoms were intense neuralgic pains in the front and back part of the head, over the ribs on both sides, and in the left arm. Whole nights she had passed without sleep, and, as a natural and inevitable consequence, her appetite was weak and capricious, and her bowels irregular. Her left arm was not only exceedingly painful, but it was also so much affected with functional or reflex paralysis, that she could not raise it from her side. She experienced temporary relief immediately after the first *séance*, but the pain returned on the following day.

After the fifth application there began to be evidence of improvement in her general condition, though her neuralgic symptoms were but temporarily abated, and her left arm seemed to be as powerless as before. After she had been under treatment for about three weeks, she was attacked in the night with such a severe paroxysm of neuralgia of the uterus, that her friends became greatly alarmed. Treatment by general electrization was renewed, and her improvement was very rapid. The neuralgia of the left arm began to yield, and with it the temporary paralysis.

Her appetite became almost ravenous, and her rest at night was very comfortable and sometimes unbroken. Her face was fuller and she increased in weight.

The treatment was extended over a period of seven weeks. Her menses appeared twice during that time, and were comparatively painless. After the treatment was discontinued, she still further improved, with only occasional slight relapses of pain. In regard to this and a number of very similar cases treated by general electrization it may be remarked that the special symptoms—neuralgia, headache, constipation, etc.,—were dependent on general feebleness, and that these special symptoms did not ameliorate or depart until the general system began to be strengthened. In a word, the cure was wrought by the tonic effects of general electrization.

In the course of the following year the patient relapsed, under a combination of unfavorable influences, and was taken to a hospital.

General neuralgia of five years' standing, associated with great debility, menorrhagia, and distressing anæsthesia—Treatment by general faradization—Approximate recovery.

CASE 30.—Mrs. S., a married lady, aged thirty, had suffered from several miscarriages, and had been treated for a long time for ulceration of the neck of the uterus, that finally yielded to local applications.

Up to her twenty-fifth year, she had enjoyed a good degree of health; but after her first miscarriage she began to suffer from prolonged menstruation, attended with an excessive flow. This state of things had existed but a few months, when the patient experienced certain wandering pains over the body, that became more marked at each return of the catamenia, until the paroxysms assumed a most distressing character. They were usually ushered in by tenderness and a sensation of oppression in the epigastric region. Throughout the whole attack the most acute pain would be felt over the stomach, and was attended with vomiting. *Most of the body was, however, to a greater or less extent, affected by the disorder.* The head became tender to the touch, the eyes intolerant to light, and the tongue and mucous surfaces of the cheek would be affected by a very annoying sensation of numbness. Several times a year she was prostrated by symptoms that were very sudden in their onset, and exceedingly alarming in character. The pulse would fall to forty-five or fifty in the minute, almost without warning, and become so feeble as to be hardly perceptible. The power of articulation left her, the anæsthesia of the mouth and tongue became complete, and the face assumed a most deadly color and coldness.

These attacks lasted from twenty minutes to half an hour, and were treated by the free use of brandy and carb. of ammonia.

An application of the faradic current, given one evening during a periodical monthly paroxysm, so relieved the distress that a quiet night was the result. After this we found that a similar application would invariably relieve the pain. The main idea, however, was to strengthen the general system and so prevent these attacks. For this purpose, she was treated thoroughly by general electrization on every other day.

In the course of a few weeks her power of endurance had increased considerably, and, when the menses appeared, they were of shorter duration, and attended with a much less loss of blood than before. The neuralgic pains were incomparably less severe, and she rallied to her usual condition immediately after the attack. After remaining under treatment several months, she was discharged as approximately cured. More than a year has elapsed since treatment was discontinued, but she has not suffered from another of these occasional prostrating attacks of which mention was made. Her menses continue regular and normal, and it is only after great provocation that she ever experiences paroxysms approximating in severity to those of former days.

It is unquestionable that many of the cases of neuralgia that have been regarded as constitutional, are really of central character.

In proportion as our diagnosis becomes exact, in that proportion will the class of central neuralgias increase, and that of constitutional diminish. The locality of the pain may be at the most distant point possible from the locality of the disease. It is probable that the neuralgic pains in the limbs that are premonitory of locomotor ataxy, myelitis, spinal irritation, etc., have often been classed as constitutional.

CENTRAL NEURALGIA.

Central neuralgias may be subdivided into two classes:

1. Those where both the *disease* and the *pain* are central. Under this head are included cephalalgia, variously known as headache, migraine, hemicrania; and pain in the spinal cord, known as *spinal irritation*, or spinal neuralgia.

2. Those where the *disease* is central, though the *pain* is peripheral. This subdivision is larger and more important than is generally supposed. Very many cases of facial, cervico-brachial, brachial, intercostal, and sciatic neuralgia, as well as gastralgia, and

neuralgia of the abdomen and lower limbs, are of a central origin, and should be treated accordingly.

The diagnosis of central neuralgias, in which the pain is peripheral, is a matter of very great importance in the prognosis and therapeutics.

The characteristic features of this form of neuralgia are:

1. The momentary stabbing, *boring*, lancinating character of the pain, that seems to be felt in the bones. The pains of locomotor ataxy, myelitis, spinal irritation, are usually of this character, and are usually more or less fugitive or wandering.

2. The "tender points" are usually painful only during the attack of pain, not as in neuritis, during the intervals.

3. The history of the case frequently points to other symptoms which indicate central disease.

4. Section of the nerve affords only temporary relief. The failures that have resulted from section of the fifth pair in tic douloureux are due to the fact that the disease is usually of a central character.*

Cephalalgia (*Headache—Cerebral Irritation.*)—Headache, in its different types, is a form of central neuralgia that is always exceedingly frequent among all classes where the nervous diathesis prevails. Its types are manifold. The brain, in reference to pain, is very largely a vicarious organ, since it suffers for the sins of all the rest of the body. Not only all diseases of the brain itself, but also all derangements of the viscera, of the genital organs, may give rise to some type of headache. Poisons in the blood, whether of drugs or of toxic disease, and all depraved and exhaustive conditions of the blood or of the nervous system, may have headache for a symptom. Headache—using the term in its widest sense—may therefore, be a symptom of almost any conceivable form of constitutional or local disease.

The term cerebral irritation might, perhaps, be as truly applied to headache, in very many of its types, certainly as spinal irritation to a recognized morbid condition of the spinal cord. That form of headache which is accompanied by *soreness*, *heat*, *and burning*

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* For interesting remarks on the character of the pain in neuralgia, see Benedikt, op. cit. p. 104.

pain on the top of the head, or on the temples, and by tenderness of the scalp, seems to be quite analogous to spinal irritation. It occurs in the same class of constitution as spinal irritation—that is, the nervous diathesis, and is often associated with it. It seems to be brought on by the same exciting causes, and to be relieved by the same methods of treatment as spinal irritation. The two conditions often alternate, or they may exist together. The pain in cerebral irritation may be on the brow, or on the top, back, or sides of the head. The tenderness of the scalp may be either confined to one spot or extended over a considerable surface. This tenderness is sometimes so excessive that a single touch of the hair causes distress. Cerebral irritation may be accompanied by tenderness of the cervical sympathetic. The feeling of heat and burning on the top of the head cannot be regarded as necessarily symptomatic of disorders of the uterus, as is quite generally held by the profession, since it is by no means confined to the female sex. We have observed a number of typical examples of this symptom in males.

Concerning the pathology of cerebral irritation we are left to conjecture. That there is frequently a hyperæmic condition is rendered probable by the fact that the pain is relieved by bromide of potassium and hydrate of chloral, which reduce the volume of blood in the brain, and is aggravated by whatever influences increase the amount of blood in the brain. And yet we have no right to assume that hyperæmia is the usual condition in such cases, since it is just as fair to suppose that molecular derangement, or anæmia, might account for all the symptoms.

Hemicrania (*Sick-Headache*), (*Migraine*). — This affection comes on with haziness, dulness, heaviness, at once undefinable and oppressive. Its progress is marked by derangement of all the vital forces—by general agony and distress, that render exertion of brain or muscle almost impossible.

When accompanied, as it often is, by vomiting, by abstinence from food, and from all exertion, sick-headache appears to be as much a remedial process, and as necessary and beneficial to the system, as a thunder-storm to the atmosphere.

The affection is usually accompanied by a sharp or dull pain in the forehead, and especially through the left eye. The general depression that accompanies the attack seems to bear no relation to the severity of the pain; for ordinary neuralgias, even when far more severe, are not half so depressing, and do not interfere to the same extent with the processes of thought.

It is more than probable that the sympathetic or ganglionic system is chiefly at fault in sick-headache, and by this theory we may explain the fact that it is brought on or aggravated by such diverse causes. The vomiting that is an accompanying symptom, sometimes relieves the distress, but frequently aggravates it. The common idea that sick-headache is the result of the accumulation of bile, or indeed of any local disorder of the digestive apparatus, is mostly erroneous. In the majority of cases, the vomiting is itself the *result* of the attack of headache, which in its turn is the result of some cause that has acted injuriously on the *nervous system*, such as great excitement, anxiety, prolonged abstinence from food, or some undue mental exertion. It is probable that indigestion brings on sick-headache chiefly through its effects on the nervous system.

Electro-diagnosis in headache frequently detects abnormal and excessive tenderness on the top of the head, and also certain very tender points on the forehead, and sometimes on the parietal bones. In sick-headache the eye of the affected side is sometimes exceedingly sensitive to the current. Electric examination of the head is only of value for those who are thoroughly familiar with the normal sensitiveness of the different parts of the cranium to the electric current. In health the front, sides, and top of the head are very sensitive to the current, the back of the head very much less so. (See cuts 54 and 55, pp. 255, 256.) *In some pathological cases all parts of the head so far lose their sensitiveness that they can bear a current of very considerable strength without discomfort.* Concerning the precise significance of this symptom we have no means of deciding; but from our limited experience it would appear to be, so far as it goes, an unfavorable indication.

Treatment.—Headache should be treated by general or localized electrization, according to the indications of each case. Dry faradization with the hand is used successfully. Stable galvanization or faradization, uniform or increasing, may be employed. Labile applications with the moistened hand are sometimes of service. Sometimes the pain is relieved in the midst of the sitting. General electrization is more effective than localized, for the reason that in so large a proportion of cases the pain in the head is so very frequently symptomatic of disease of other parts of the body, the precise nature and locality of which we cannot possibly detect. Galvanization of the sympathetic is sometimes of service; but, for the reason just stated, no forms or modifications of localized electrization can be as efficacious as general. Relief not unfrequently follows galvanization or faradization of the stomach, or bowels, or spine, or galvanization of the sympathetic, even when the head is not touched. *Applications to the back of the neck are sometimes more efficacious than direct applications to the head.*

Prognosis.—Although headache in this country is even a more frequent symptom than dyspepsia, yet patients do not usually apply for treatment for this symptom alone, but only when it is associated with more special and distinct affections. The immediate effects of electrization in headache are as variable as the pathology of the symptoms. It sometimes relieves, sometimes aggravates, and sometimes gives only negative results. In very many of our cases of dyspepsia, of anæmia, chlorosis, nervous exhaustion, paralysis, headache is a more or less constant symptom, from which during the treatment they usually obtain either relief or cure. In rare cases all other symptoms yield but this.

Persistent and constant cephalalgia of long standing: anæsthesia of head—No relief.

CASE 31.—Mr. R., a clerk, aged 22, was referred to us, April 22d, 1869, by Dr. Hallet, of Brooklyn. The young man had been many months a sufferer from persistent pain through the head, in all parts of it, even to the back of the neck. Treatment had been of no avail. His constitution was of the nervous variety, and his symptom was aggravated by his sedentary mode of life, and by any sustained mental effort.

Electric examination with both galvanic and faradic currents demonstrated a very unusual *lack of sensitiveness to the current on all parts of the head*, which in health can bear only very gentle currents. All modifications of electrization were employed, general and localized galvanization and faradization, for four weeks, without making the feeblest impression on the symptom. No temporary relief could be obtained either during or after the sitting. The strangest and most unusual fact of all was, that the symptom could not be temporarily aggravated or changed in its character, even by powerful and somewhat prolonged galvanization.

The failure was complete; after four weeks' treatment the patient was dismissed, no better and no worse than at the outset of the treatment.

Recently Dr. Vansant has revived the use of magnetism in headache, as well as in some other forms of neuralgia. He uses a *straight* magnet about 8 inches in length and ⅛ of an inch in width. The + pole, applied for a few seconds at the painful spot, was found to increase the pain, while the — pole diminished it. The cases published are not sufficient in number or importance to establish the claims of magnetic * superiority over the various methods of electrization in the treatment of neuralgia. He relates the following cases:

"Mr. J. R., a gentleman of rather delicate organization, had neuralgia in the upper part of one side of his face. I applied the northward (—) pole of a small bar magnet, not quite capable of lifting half an ounce with one pole, for a few seconds over the painful place. In about ten minutes he said the pain was increased and more localized. I then applied the southward (+) pole in the same way, and in a few minutes he said the pain had nearly ceased. This gentleman expected to be relieved by the *first* application.

"Mr. ——, a strong, unimaginative man, had facial neuralgia of malarial origin. I applied the — pole of the same small magnet, last described, over the seat of pain for about one minute. In five minutes he complained of the pain being worse. I then made an application of the + pole, and in less than a minute the pain almost subsided. After about an hour there was a recurrence of pain for a short time, but much lessened in intensity. This person was led to expect relief by the first form of application. (I have repeated the above experiment on myself with similar results.)"

It must be admitted, however, that no very important therapeutical results have yet been obtained by the magnet. It has been found that, as a rule, it is necessary that the patient should be of a peculiarly impressible organization in order to yield to its influence.*

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* Psychological Journal, April, 1869, p. 281.

In many of the cases of dyspepsia, neurasthenia, anæmia, and hysteria, headache was a prominent symptom, which was not only temporarily but permanently relieved by the treatment. If we were to judge from our own observations, electrical treatment is even more efficacious to *prevent* attacks of headache, by improving the tone of the system, than to dissipate the pain after it has once set in.

The results of our treatment of sick-headache by electrization have not thus far been very encouraging.

Neither our notes nor our recollection enable us to cite a single case of positive cure of a long-standing tendency to sick-headache, by the use of general or localized electrization.

Sick-headache — Vomiting—No relief from faradization.

CASE 32.—The onset of the pain was very peculiar. Without the slightest warning, when at church or walking, at the piano or engaged in household duties, her vision will become blurred. Objects before her seem to dance about in every direction, and she is unable to recognize familiar faces. No barometer is so accurate in indicating storms as are these nervous symptoms in foretelling the commotion about to take place in her system. Soon the blur before the eyes partially disappears, and a most raging headache sets in. The arteries in the temples swell, and pulsate with great rapidity and force. Sharp lancinating pains dart all over the head and through the eyes. As a rule, vomiting of a grumous-looking liquid, mixed with bile, accompanies the other symptoms. After lasting from 12 to 24 hours, the severity of the attack abates, leaving her in a somewhat debilitated state, from which she soon recovers. Electrization failed to give any relief. Bromide of potassium is the only remedy that has any effect whatever. Given in doses of 20 grs. as soon as the eyes become blurred, it will frequently lessen the severity of the pain in the head.

In the other case the headache is preceded by no blurring of the eyes, but is accompanied by an excessive and distressing sense of *nervousness*, causing the patient to throw her limbs and body about, and to "feel," to use her own expression, "as if she would fly." A number of applications of the faradic current enabled her to overcome this feeling of nervousness, and thus relieved her of one very annoying symptom of her disorder. Generally, though not always, in the cases just related, these attacks of sick-headache occur just before or during the menstrual period, and so would seem to be influenced in some measure by this function.

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* Tripier (Annales de l'Electrothérapie, 1863), presents a résumé of some not very convincing experiments of l'Abbé Le Noble in the treatment by the magnet of headache and other nervous affections. The experiments were recorded by Andry and Thouvet, in "Mémoire sur le Magnétisme Médicinal." Paris, 1782.

In some cases of sick-headache we have succeeded in temporarily relieving the pain by electrization, even in the midst of the application. This result, however, is by no means uniform. The true principle of treatment is to tone up the system by a persevering use of *general* electrization, with other tonics, so that the paroxysms may be less frequent and less severe; in other words, to combat the *nervous diathesis* of which the sick-headache is but a symptom.

FACIAL NEURALGIA—(EPILEPTIFORM NEURALGIA—FOTHERGILL'S DISEASE—TIC DOULOUREUX).

Facial neuralgia appears under two forms. The mild form is usually of a peripheral character, being caused by neuritis, pressure from effusion, decayed teeth, or morbid growth. This form usually yields readily and surely to electrization. The severe form, to which Trousseau has given the name epileptiform neuralgia, is of a central character, being caused by a variety of pathological conditions of the brain.

The symptoms of this form of facial neuralgia are the spasmodical and very intense character of the pain in the course of some of the branches of the fifth pair. The spasms are of very short duration—ten to fifty or sixty seconds—and may be accompanied by convulsive action of the muscles. The attack may be brought on by any exercise of the jaws, as chewing, reading, eating, or talking. The pain is so great as to cause the patient to slap his face, or frantically rub the spot over the seat of the pain. Sometimes patients who have great self-control stamp violently on the floor, jump up if they chance to be sitting, pace the room, and utter piercing cries.

This terrible disease has usually been regarded as almost incurable, and is so pronounced by Trousseau, who has graphically described its symptoms.* Section of the nerve, of which so much

* See his Lectures, Bazire's Translation, part 1, p. 105.

was once expected, is now but seldom used, and permanently succeeds only in exceptional cases.

By a judicious and varied use of peripheral faradization or galvanization, or by the electric moxa, or by galvanization of the brain or cervical sympathetic, a certain portion of these terrible cases can be relieved or cured. Our experience does not yet enable us to say what proportion the failures will bear to the successes; but if one case out of ten can be relieved or cured, it is justifiable to try electrization in all, since other modes of treatment offer no hope.

We present typical examples of both failure and success in the electrical treatment of this disease.

Epileptiform neuralgia of left side of face, of two years' standing, treated without benefit by various methods of electrization.

CASE 33.—Mr. P., aged —, was sent to us, Nov., 1869, by Dr. Willard Parker, with typical symptoms of epileptiform neuralgia. The patient, though a man of mild temperament, stamped furiously on the floor, even while telling us his history. The spasms of pain appeared in one spot, in the course of the lower branch of the trifacial. The general health of the patient was not greatly impaired, although he had suffered for two years.

We tried, in succession, all means of electrical treatment, with both currents. At one time some temporary benefit appeared to have been derived; it was, however, of short duration, and the paroxysms returned in full force.

After ten applications the patient abandoned treatment, utterly disheartened.

In the above case we made the applications twice a day, as the patient could stay but a short time in town. It is possible that better results would have followed if a longer interval had been allowed.

Epileptiform neuralgia, of two years' standing, in an aged patient—Aggravation of the symptoms by general electrization.

CASE 34.—Mr. ——, aged —, consulted us in March, 1870, for spasms of pain in the lower branch of the trifacial, that had distressed him for two years. His pain, though not of the severest kind, was yet terrible. His under lip hung over, and the saliva dribbled from his mouth.

The whole round of remedies had been tried in vain.

With a fair understanding of the probabilities in the case, we treated him two or three times with both currents, and in various methods of application.

Seven applications were given. The currents were mild and the séances short, but each time the patient went home suffering more than when he came. At the close of the treatment, it was evident that the patient had become much worse. He soon rallied, however, from the temporary aggravation of his symptoms to the condition in which he had been prior to the treatment.

An additional evidence that the disease in this case was central, was afforded in a feeling of numbness that the patient at times experienced in the right hand and foot.

We now turn to the pleasanter side of the picture.

Epileptiform neuralgia of two years' standing—Improvement under faradization temporarily aggravated by galvanization.

CASE 35.—Mr. M., aged 65, of extraordinary vigor of constitution and perfectly temperate in every habit, stated that some two years since, in the year 1865, he first noticed a slight pricking sensation under the lobe of the left ear. For one year this feeling occurred only occasionally, and annoyed him but little. At the expiration of this time the attacks became more frequent, were considerably prolonged, and produced actual pain.

It was a singular feature associated with his condition, that exposure to the sun's rays for a few moments would invariably occasion an attack of pain. About this time the loss of a large amount of money was a cause to him of great anxiety of mind, and evidently aided in aggravating his disorder. The paroxysms of pain increased in frequency and severity, until it was his sorrow

From this time onward, under the exclusive use of the faradic current, the improvement was uninterrupted, until, after remaining under treatment six weeks and receiving eighteen applications, he was discharged approximately cured. Occasionally, after a long conversation, he feels something like a twinge of the old pain, but it is so slight as to give him little annoyance.

The following very remarkable cases we transcribe from the *Practitioner*:—

"*One case of facial neuralgia, of twenty-nine years' standing, cured by the galvanic current in twenty sittings—Subsequent relapse and relief—Also, a case of facial neuralgia of few years' standing, cured by galvanization, after the failure of section of the nerves.*"

"Dr. Wiesner, of Tübingen, relates two interesting cases of severe and standing neuralgia, treated in Niemeyer's clinic. The first was that of a man seventy-four years old, who had suffered for twenty-nine years from neuralgia affecting all three branches of the trigeminus. All manner of treatment had been tried, with no good results; there was a red and infiltrated spot of skin three-quarters of an inch long, below the orbit, on the affected side. The constant current was applied, the painful parts being included between a moist positive pole and a negative pole armed with a metallic brush. Great improvement was rapidly produced, and after twenty sittings only a slight sensitiveness of the upper lip remained. Several months later there was a relapse of pain; this was treated by Dr. Niccolich, of Trieste, by the use of Gaffe's electric apparatus, with the direct (galvanic) current, and quickly removed; the sensitiveness of the upper lip was also got rid of by applying one electrode deeply within the nostril. The second case was that of a man aged sixty-four, a sufferer from facial tic for five years. All other remedies having proved vain, Professor Billroth divided the infra-orbital nerve, and on the recurrence of the pains repeated the operation, with resection of a portion of the upper jaw. The buccinator, the posterior dental and mental nerves were successively resected in vain; and finally, the common carotid was tied (!), with only temporary relief. At the time when the galvanic treatment was commenced, the pain was chiefly in the temporal nerve, and also in the infra-orbital. The painful parts, and also those which were sensitive on pressure, were included in a current passed between two moist sponge electrodes; two séances of five minutes each were given daily. Improvement soon occurred, but was often chequered by relapses. One electrode was now introduced into the mouth, and the other applied to a corresponding point in the cheek, and the improvement became rapid. In two months all attacks of pain had ceased, and one month later the patient no longer remained sensitive to the influences which formerly excited attacks."—(*Berlin. Klin. Wochenschrift*, 17 and 18, 1868.)

SPINAL IRRITATION (SPINAL NEURALGIA).

Spinal irritation is one of those names which, like hysteria, have become the recognized property of the profession, against the actual or implied protest of nearly all who employ it. The term *spinal neuralgia* would seem to better express the symptoms and the condition usually embraced under spinal irritation, since it would be very well consistent with the received nomenclature of neuralgia, and in some respects, at least, would not incorrectly express the nature of the affection.

The term spinal irritation, originally proposed by Dr. Brown of Glasgow, and described and illustrated in detail by G. T. P. Teale, in 1829, and the Griffin Brothers in 1844, is now pretty generally understood, in England and America, at least, to express a tolerably well defined morbid condition, of which one of the leading symptoms is spinal tenderness.

Prof. Niemeyer* speaks slightingly of the term spinal irritation, evidently not regarding it as worthy to be classed among diseases. Romberg† declares that the investigation of spinal irritation, of which he speaks under the head of spinal neuralgia, has contributed nothing to Physiology, Pathology, or Therapeutics.

German writers in general, we think, discard the term, or at least are unwilling to bring it into the nomenclature of diseases. Among American physicians it by no means occupies the position that it held twenty-five or thirty years ago; indeed, it may be said that the tendency has been to dismiss the term altogether. But of late years, under our improved methods of studying and treating nervous diseases, there would seem to be a disposition to return to the views that were held on this subject in 1840.

In Reynolds' System of Medicine, Dr. C. B. Radcliffe treats of spinal irritation as a distinct and recognized affection, in the section devoted to diseases of the spinal cord.‡ More recently still, Benedikt, of Vienna, speaks of the affection, though not in detail, under the head of hysteria, of which he regards it as an incidental symptom.* Recently Dr. W. A. Hammond † has published an interesting paper on this subject.

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* A Text-Book of Practical Medicine, translated by Drs. Humphreys and Hackley, 1869. Vol. ii., p. 258.

† Manual of the Nervous Diseases of Man. Translated by Edward H. Sieveking, M.D. London. Vol. i., pp. 154 and 155.

‡ Vol. ii., p. 690.

One reason why the German physicians have been unable or unwilling to accord to spinal irritation the prominence given to it in England and America, is probably that the disease or symptom of disease, by whatever name it is called, is less frequent among them than with the Anglo-Saxon race. The simple fact is that spinal irritation or spinal neuralgia is one of many manifestations of the nervous diathesis, and is therefor most frequent and most severe where the nervous diathesis prevails.

Among the leading symptoms are spinal tenderness, pain in the spine, with a feeling of heat and burning; fugitive neuralgic pains in various parts, that seem to have a relation to the tender parts on the spine; chills, formication, fits of yawning, stretching, sneezing, gaping; nervous or spasmodic cough; nausea, palpitation, irritable bladder, constipation, insomnia, and muscular contractions.

Irritation of the cervical vertebræ is likely to be accompanied with headache, spasmodic cough, or possibly with aphonia or with dysphagia; irritation of the dorsal vertebræ with gastric disturbances, or with neuralgia, or tingling of the fingers and weakness of the arms; irritation of the lumbar and sacral vertebræ, with derangements of the bowels, of the genital organs, pains and weakness in the lower limbs. Among other symptoms that are observed in spinal irritation, are sudden startings in the sleep, or spasmodic jerkings just as one is on the point of dropping to sleep, twitchings of the muscles in various parts of the body, and persistent mental depression and tenderness of the cervical sympathetic. In males there may be either diminution of the sexual power, or morbid excitability, or alternations of both conditions; in females there may be almost any conceivable functional disturbance of the genital organs.

A review of this array of symptoms—many of which are common to a variety of diseases—shows that the differential diagnosis of spinal irritation must frequently be a matter of considerable difficulty.

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* Die Electrotherapie, p. 417.

† Psychological Journal, April, 1870.

The muscular contractions may be so powerful as to bring up the thighs against the abdomen.

Pressure on the tender vertebræ sometimes brings on cough, pain in the parts corresponding, or to a thrill over the body ; and, in extreme cases, may produce fainting.

The statistics of spinal irritation compiled by Griffin Brothers is of some interest. Of 148 cases, "26 were males, 49 in married women, and 73 in girls." Of these cases 28 had the spinal tenderness in the cervical region, 46 in the cervical and dorsal, 23 in dorsal, 15 in dorsal and lumbar, 13 in lumbar, 23 in all regions of the spine.

Differential Diagnosis.—The truth is that spinal irritation almost always forms a part of one or more of the diseases, as hysteria, chorea, spinal hyperæmia (congestion or meningitis), &c., constituting, as it were, a subdivision or accompaniment of them, and is only entitled to the honor of distinct nomenclature by itself *when the spinal tenderness and the symptoms that directly flow from it overshadow other accompanying conditions.* Close examination would reveal that very many of the cases in practice that are variously classified under hysteria, anæmia, etc., have a sufficiently marked tenderness of the vertebræ to be regarded as examples of spinal irritation ; and if treated accordingly, would recover more rapidly than under the methods usually employed. The best confirmation of the diagnosis is the very favorable result of judicious and varied treatment devoted specially to the tender spots on the spine.

Between spinal irritation and spinal meningitis or congestion, the distinction is oftentimes purely one of *permanence and degree.* In both conditions there may be pain and heat in the spine, neuralgia or paralysis of the limbs, plantar heat and anæsthesia, constipation, feeling of pressure or constriction in the chest, and stiffness of the neck, etc. Spinal irritation, when hyperæmia exists, may run into spinal congestion or meningitis—the latter being simply an advanced stage of the former. It is distinguished from myelitis by the absence of other necessary symptoms. The contractions of muscles in spinal irritation are less painful than those of myelitis.

Pathology.—In spinal irritation, as in cerebral irritation, there may be either anæmia or hyperæmia. That very many of the cases of spinal irritation depend on hyperæmia of the cord is quite conclusively shown :—

1. By the feeling of heat and burning at the seat of the irritation.

2. By the fact that this pain is frequently increased at night, when the patient is in a recumbent position.

3. By the fact that it is relieved by measures that relieve congestion, as dry and wet cupping, and by blisters over the tender vertebræ.

On the other hand, reasoning from analogy and from what we know of the relation of the sympathetic, it is proper to assume that anæmia exhibits as many of the phenomena of spinal as of cerebral irritation. This assumption is strengthened by the fact that very many of the patients who have spinal irritation are more or less anæmic. And yet, reasoning from the history of the cases, and from the results of treatment, we are inclined to the opinion that anæmia exists only in a small minority of the cases of spinal irritation ; that in the majority of instances there is more or less at least *temporary* congestion of the cord and of its membrane ; and that in all cases of doubt it is safe to assume the existence of hyperæmia, and to guide the treatment accordingly.

It is not necessary to assume that this hyperæmia of the cord is a constant condition. Except in the severe and long-standing cases, it is probably not so, but is more or less evanescent, temporary, and metastatic. This may distinguish it from spinal congestion, which is a fixed condition. Congestion of the cord, as of the brain, the genitals, the eye and the ear, may perhaps be easily excited. It is not unreasonable to suppose that anæmia and hyperæmia may alternate in the patient, and in the same day or hour.

The question can of course only be definitely settled by examination of the cords of those who have died while suffering from spinal irritation.

Causation.—Spinal irritation, like all other developments of the nervous diathesis, may arise from any causes or combinations of causes that weaken the nervous system. These special causes, whose name is legion, may all be included under these four heads: *excessive, spasmodic, or disproportionate mental labor, and especially anxiety; excessive excitation of the genital organs, either in the natural or unnatural way; improper or insufficient nutriment; and lastly, exhausting physical toil, especially in the form of long walks or marches.* As a matter of observation, the condition is usually brought on by a combination of two or three, or perhaps all of these general causes, acting on a constitution hereditarily disposed to nervous disease. The special part which excitation of the sexual organs plays in the causation of spinal irritation is very difficult to interpret, or at least to differentiate.

It is the opinion of Dr. Radcliffe that abstinence from alcoholic stimulants is a fruitful cause of spinal irritation, and he states that he finds it impossible to cure a case without the aid of some form of alcohol. The subject is variously complicated with questions of race, climate, and habits of life; but it is, to say the least, a very suggestive fact that the better classes of the United States are the only civilized people who do not make habitual use of some form of alcoholic stimulants; and it is among these very classes that spinal irritation, and most other manifestations of the nervous diathesis, are most frequent.

Electric examination in spinal irritation may sometimes reveal tender spots on the spine that are not indicated by pressure.

Treatment.—Electric treatment consists in general electrization, galvanization of the spine and sympathetic.

Galvanization of the cord may be performed without regard to the direction of the current, one pole (better the positive, see p. 165) being placed over the tender spots, and the other on some indifferent point by the side of the spine and at a short distance from it. To depend on localized galvanization alone is illogical, since the disease, though for the time specially localized in the spinal cord, is usually simply but a development or manifestation of the nervous diathesis, in which the whole system shares.

Prognosis.—Under electric treatment alone, the prognosis of spinal irritation is usually favorable for a relief, and sometimes for permanent cure.

It is, however, of great advantage in all severe or long-standing cases, to combine with electrization, counter-irritation (blisters, or tartar-emetic ointment) over the sensitive vertebræ, and the internal administration of phosphorus or other stimulants. In nearly all of our cases we have used only electrization, either because they refused other treatment or had previously tried it with unsatisfactory results. It is probable that neglected cases may sometimes go on to locomotor ataxy, or myelitis; but on this subject there is need of accurate clinical observation.

Comparative rest of brain and muscles is an important, though not indispensable, aid to treatment. The disease is quite prone to relapse, especially under bad hygienic surroundings. Under combined treatment, consisting of blisters to the spine, phosphorus, strychnia, and electrization, the majority of cases will rapidly improve. So many of our cases of spinal irritation are included under other diseases, as hypochondriasis, hysteria, nervous dyspepsia, etc., that statistics of the results of our treatment in this special symptom cannot well be prepared.

Spinal irritation of four years' standing, with excessive tenderness in the lumbar region—Decided relief from general faradization.

CASE 36.—Mrs. ——, aged 24, was sent to us Jan. 4th, 1868, by Dr. Sewall, to be treated for pain, with most excessive tenderness, over the lumbar vertebræ. The symptoms had been particularly distressing since her confinement, two months previous, but had annoyed her more or less for four years. United with this spinal tenderness there was considerable debility, that made a walk of half a mile a burden; gastric uneasiness, feeble appetite, insomnia, and, in general, the characteristic features of the nervous constitution.

Electric examination revealed a very great tenderness over several of the lumbar vertebræ; only a feeble current could be borne at all, even with large, soft sponges. No other abnormal condition was found beyond a general hypererethisia, which is usual in such cases. The tenderness was so great that even the weight of the hand was distressingly painful.

We began treatment by general faradization, with special reference to the tender spot in the spine. At this locality we used a stable-increasing current, beginning with a current scarcely perceptible, and increasing the strength up to the point where it could be comfortably borne. The patient shortly improved under this treatment, though not without relapses whenever she attempted any important exertion. From week to week the tenderness became less marked, until the vertebræ were no longer painful under moderate pressure, and a much more powerful current could be borne with ease. Agreeable temporary relief followed each application—an observation which we have frequently made in spinal irritation.

At the end of two months the patient was dismissed very much benefited.

Hyperæsthesia of the cervical and upper lumbar vertebræ—Improvement under general and localized faradization and galvanization.

CASE 37.—Rev. Mr. F., aged 30, was referred to our care March 9, 1868, by Dr. Gurdon Buck. For several months before, he had been complaining of pain and heaviness in the back of the neck, that had compelled him to resign his pastoral charge and abstain from all sustained mental exertion. The patient was large, tall, well formed, and apparently very robust. All the functions seemed to be tolerably well performed; but sustained mental exertion was almost impossible. He had been treated faithfully by counter-irritation, in the shape of wet cupping, and had derived positive benefit therefrom.

Electric examination indicated some tenderness on the upper cervical vertebræ, and also in the upper lumbar; but this tenderness was not excessive, and a current of fair strength, so far as the vertebræ were concerned, could be readily borne without discomfort ; nor were the vertebræ so painful as they sometimes are found.

But, in one respect his behavior under the electric examination was peculiar. The sensation produced by a mild galvanic current over the upper cervical vertebræ was painfully felt in the forehead, indicating a morbid irritability of the central nervous system, since in health such a phenomenon does not appear. That this morbid irritability was in some way related to the sympathetic, or that, at least, the sympathetic was the medium through which it was manifested, was rendered probable by the fact that mild faradization or galvanization of the affected part caused a very profuse perspiration on the hands and feet. This same effect we have also observed in a case of hysteria.

Strong as the patient appeared to be, it was necessary to treat him with mild currents and short applications. By turns and in succession we tried the various methods of electrization, with both the faradic and galvanic currents, and with important though not brilliant results.

After a treatment extending by intervals through three months, the patient left for a visit in England, where he remained nearly a year, still slowly improving.

Irritation of cervical vertebræ following uterine disease.

CASE 38.—Mrs. ——, wife of a physician from the interior of the State, consulted us in the spring of 1868, for a dull, heavy, and persistent pain in the back of the neck, that for some time had troubled her, and which did not seem to yield to the various treatments that had been employed. Her general health had not been good, and at one time she had suffered from and had been treated for displacement of the uterus.

Electric examination indicated a decided, but not remarkable tenderness over the painful vertebræ.

We advised general faradization, and made three applications, which were followed by some relief. The patient was obliged to return to her home before we had time to give her a thorough course of treatment.

The above case is one of many illustrative of the fact that spinal irritation is a result of, or at least follows, disease or morbid symptoms in some other part of the body. Very frequently have we observed that it is preceded, perhaps for years, by dyspepsia, sick-headache, or by morbid condition of the genital organs.

A chronic condition of irritation and hyperæsthesia of the spinal cord greatly benefited by general faradization, in conjunction with galvanization of the sympathetic and spine.

CASE 39.—A young lady, daughter of a physician, who had suffered for many months from symptoms both of congestion and irritation of the spinal cord, was placed under our care by the advice of Dr. H. D. Bulkley. Tenderness was manifest over the cervical-dorsal and lumbar regions. The patient complained of shortness of breath, numbness and tingling in the hands and feet, cough, nausea, with neuralgic pains around the loins and in the extremities. A very decided loss of power was manifest in the lower limbs, so that it was impossible to take more than a few turns around the room without fatigue. Under the tonic influence of twenty general applications of the faradic current, the patient very decidedly improved. The tenderness along the spine decreased, and in the cervical region disappeared altogether.

The shortness of breath, the numbness and tingling, together with the neuralgic pains, became less marked, while the strength so far improved that she was able daily to take short walks of several blocks, and to ascend the stairs with comparative comfort.

We now resorted to the galvanization of the sympathetic and the spine—spinal-cord current—which were followed by an improvement more marked than it was possible to obtain from the faradic current alone. The patient is still under observation, and is far from well. She may never completely recover; but, in consideration that a tendency to these symptoms had existed from her very birth, the improvement has been as rapid as could be reasonably expected.

A condition of tingling, pricking, and a disposition to paralysis of the legs, dependent on irritation and hyperæmia of the cord, decidedly relieved by galvanization of the sympathetic and general faradization.

CASE 40.—Mrs. W., aged 44, whose physician, Dr. H. Gregory, advised treatment by electrization, was suffering from pricking sensations in the arms, and from tingling and numbness of the lower limbs and feet. In the legs, also, there was a decided "*disposition*" to paralysis, as manifested by a feeling of weight in the effort of walking.

Pressure along the spine disclosed a tender point, at about the third dorsal and second lumbar vertebræ. These conditions of tenderness, tingling, and weight in the lower limbs seemed to indicate not only an irritation, but also a hyperæmia of the spinal cord. Galvanization of the sympathetic and mild general applications of the faradic current were followed by a marked amelioration of these symptoms.

The limbs especially progressed rapidly, and after eight applications became quite strong, and were quite relieved of the anæsthesia. Some tenderness along the course of the spine still remained, with occasional tingling in the extremities, but not sufficient to occasion the same annoyance as before.

We have found that the sudden, shooting pains which so frequently accompany locomotor ataxy may at times be very appreciably relieved by a judicious use of electrization.

CASES OF A DOUBTFUL ORIGIN.

Cases of neuralgia continually occur in which it is difficult or impossible to make a diagnosis of the seat of the disease.

An unusual and persistent sensation of pricking over the entire surface of the body, probably due to some morbid condition of the sympathetic—Relieved by general galvanization.

CASE 42.—Mr. L., aged 40, complained of an unusual condition of dryness of the skin, accompanied by frequent and prolonged sensations of pricking and tingling over the entire surface of the body, from the head to the feet.

The patient was a spare man, enjoying fair general health, but of a naturally nervous organization. General applications of the faradic current afforded no relief.

The galvanic current was then made use of by the method of general electrization.

The immediate effect was a feeling of irritation, which, however, instantly disappeared on the application over the body of a gentle faradic current.

This treatment afforded relief for several days, when the old feeling returned. A similar application secured the patient a longer immunity from his unpleasant sensations. Subsequent applications failed to entirely remove the evil, but so modified its effects as to render it far less annoying than before.

The symptoms in the above case indicated that the sympathetic was in some way implicated.

Neuralgia of the superior maxillary and ophthalmic branches of the fifth pair, followed by strabismus convergent and projection of the eyeballs—Treatment by localized faradization—Recovery.

CASE 43.—In September, 1867, the following quite novel case fell under our observation. The patient was a married lady (aged 35), who stated that in July, 1866, she was taken suddenly, during the night, with severe neuralgic pain in the right side of the face, along the course of the superior maxillary division of the fifth pair. Since the first attack the pain had been almost constant, and frequently occurred in prolonged and acute paroxysms. Before the disease manifested itself, she was of a full and stout habit, and had enjoyed good health. Her sufferings, however, made alarming inroads upon her general constitution. When we first saw her she was markedly frail and anæmic.

She was able to take but little exercise, and her appetite was poor and capricious. In April, 1868, the ophthalmic branch became affected, and the pain changed its seat, coursing along this nerve and seeming to spend itself behind the eyeballs. Strabismus convergent followed almost immediately, and the eyeballs rapidly projected, until it assumed most unsightly proportions. She had been untiring in her search for relief, but finally became deprived of hope of any amelioration of her symptoms, when the use of electricity was suggested. We made an extremely mild application of a fine faradic current, and succeeded to a considerable extent in dissipating the paroxysm from which she was then suffering.

During the two days that intervened before the second visit, she suffered, but not so severely as before. When she presented herself for the third application, she had an encouraging account to give. For three nights she had experienced absolutely no pain, and both the strabismus and the projection of the eyeballs were materially lessened. She continued to progress towards recovery during the succeeding few weeks, until her neuralgia was entirely overcome, with the exception of a slight unnatural prominence of the eyeballs. The eyes were restored to their normal appearance and position.

Neuralgia of the head, accompanied by impairment of sight and vertigo, in a lady aged 70. — Treatment by localized faradization. — Approximate recovery.

CASE 44.—An aged lady, between 70 and 80 years of age, applied to us, on one occasion, by direction of Dr. D. B. St. John Roosa, for the relief of a most agonizing distress in the head.

The pains were evidently neuralgic in character. They darted over the head in all directions, from the forehead to the occiput, but were most severe immediately behind and above the ears. The eyelids were affected to a considerable extent, seeming constricted and heavy; and sometimes, during a paroxysm of more than ordinary intensity, the sight would be much impaired for hours. When the severity of the attack had abated, she would be annoyed by a persistent dizziness, so that she could with difficulty stand erect. Previous to this attack in the head, she had suffered from similar pains that extended up the arm to the breast.

A gentle application of the faradic current to the head, during a most severe paroxysm, greatly relieved her.

Not only was the pain entirely dissipated, and the constriction and heaviness of the eyes removed, but for many hours after she was entirely free from vertigo.

The applications were continued at intervals of several days, for a number of times, and accomplished an approximate cure. Occasionally she suffers from a return of the paroxysms; but they are of a much less severe character than formerly, and are at once dissipated by the current.

The question in this case was whether the pain did not proceed from some morbid cerebral condition.

PERIPHERAL NEURALGIA.

By peripheral neuralgia is meant that form in which the cause is supposed to be seated, not only external to the nervous centres, but also in some portion or branch of the very nerve affected. These causes are various.

First. Neuritis—or more frequently, perhaps, inflammation of the neurilemma, or sheath of the nerve—is an important factor in the production of neuralgia. This inflammatory condition, again, may depend upon some form of mechanical irritation, as, for example, long-continued pressure of the child's head in labor, on the sciatic plexus, or by the concentrated poison of gout, rheumatism, malaria, or syphilis, acting locally.

Second. Neuroma of spontaneous origin, or as the result of a wound or other injury to the nerve, has long been recognized as another cause of peripheral neuralgia.

Third. The continued action of cold and wind upon a part, exhausting debility, or excessive fatigue, may give rise to the local form of the disease.

Fourth. Wounds or other injuries of the nerve.

In many and perhaps the majority of cases of peripheral neuralgia there seems to be no special cause.

It manifests itself without warning, and sometimes disappears as suddenly as it came.

Such cases would reveal after death no pathological change, but are what is commonly termed functional or idiopathic in character. Whether the cause lies in a disturbance of the electrical equilibrium, resulting in molecular change in the nerve-trunk, or otherwise, we may never know. Doubtless, however, all pain depends on structural change of some portion of the nerve-tissue, although in the majority of cases this change is so slight as to escape detection.

A strong reason for believing that a very large proportion of apparently peripheral neuralgias are really of central origin, is the fact that peripheral neuralgic pains are connected with tender points on the spine. This relation is clearly pointed out by Trousseau.* When the tenderness of the spine becomes excessive and persistent, and when it is associated with other important symptoms, it receives itself a distinct nomenclature—spinal irritation.

In whatever way we attempt to explain this phenomenon, it is certain that neuralgia reveals itself when pressure is made over the spinal processes corresponding to the point of exit of the diseased nerve. The value of this method of diagnosis is particularly marked in intercostal neuralgia, cases of which we so frequently meet. Valleix* first indicated three tender spots in this variety of the disease, viz.: the first, situated on the rib near its junction with the spinal column; the second, about the middle of the rib; and the third, near its sternal end. Long and positive experience, however, shows that this statement is not absolutely correct. The spinous processes corresponding to the intercostal space affected are the tender spots most important in the diagnosis. This point has been designated the spinous point by Trousseau, and that near the sternum the point of peripheral expansion. It is not alone in intercostal, but also in other neuralgias, that this relation of the tender points on the centre and periphery is observed.

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* Lectures translated by Bazire, part ii., p. 480.

Treatment.—The treatment of peripheral neuralgia should obviously be of a peripheral character: stable faradization and galvanization, and electric moxa. In doubtful cases, that refuse to yield to this method of treatment, it is well also to try central and general electrization.

Cervico-brachial neuralgia of left side, of six months' standing, in a patient otherwise in good health—Recovery under localized faradization and galvanization.

Case 45.—Mr. Q., a stout, vigorous gentleman, of middle life, was sent to us by Dr. Jared Linsley, April 1, 1869. The patient complained of cervico-brachial neuralgia in the left side. The pain extended from the occiput down the arm, and was most severe at night: tender point on the occiput. We judged that the neuralgia was of a peripheral character, and of a rheumatic origin.

Three mild applications of faradization gave sensible relief. Twice galvanization was tried, the negative pole being placed on the occiput, over the tender spot, and the positive on the shoulder, or on the side of the seventh cervical vertebra. After the sixth application the patient announced that he was entirely well, and discontinued treatment. Although both faradization and galvanization were manifestly of service in this case, yet the former accomplished the chief part of the task before the latter was brought into requisition.

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* Traité des Neuralgies. Paris, 1841.

The following case illustrates how utterly futile internal medication is in certain of these affections, and what a vast difference there is between the remedial power of the faradic and galvanic currents.

A very severe case of chronic gastralgia of a periodic nature—four years' standing—relieved by galvanization, after failure of faradization.

CASE 46.—Mr. B., a gentleman from Charleston, S. C., consulted us in January, 1861. The history of his case is substantially as follows: In the latter part of 1861 he was taken with a severe attack of neuralgia in the back of the head and neck. Similar attacks recurred, in paroxysms, every few weeks for about two years. In December, 1863, while suffering from severe pain, colchicum was prescribed, to be taken every two hours. Not understanding the nature of the drug, he took it every half hour for five hours. This imprudent dosing was followed by persistent vomiting and retching, which lasted for eleven days and nights, producing excessive prostration, and, in the end, total unconsciousness.

Acute gastritis supervened, from which he recovered with difficulty, but only to suffer from neuralgic pains in the stomach, similar in character and severity to the distress which he had previously experienced in the head. These paroxysms were finally subdued by quinine and opium, and for three months he was comparatively well. In April, 1864, the neuralgia in the head returned, for which he took a large dose of morphia. Excessive vomiting was again induced, followed by gastralgia.

From that time until we saw him, January, 1868, *every night had been passed in intolerable agony.* For the first few hours after retiring he would sleep with some degree of comfort; but about 2 to 2½, A.M., the invariable paroxysm would awaken him, and banish for the night all sleep. It was his custom to take immediately forty drops of the tincture of opium, which, for the time being, only aggravated the distress. By its influence, however, the pain abated in about six hours, and in the intervening time he experienced only a dull aching in the epigastric region. Time and again he had endeavored, by the advice of physicians, to gradually decrease the dose of laudanum; but all to no purpose.

It is a most singular and unaccountable fact, that xxxv. gtts. of the narcotic had no effect whatever, while xl. gtts. would act as above stated. Without the anodyne the pain was constant; but he had on several different occasions endeavored to break off from the use of it altogether.

During one trial he abstained from the opium for nearly a week; but the agony became so intense, and his strength so nearly exhausted, that, notwithstanding a resolute will, human endurance reached its utmost limit, and he was compelled to resume its use. Constant suffering had left its impress on his pale and wasted features.

He had a wild and vacant look, and his gait was weak and tottering, like that of an old man on the verge of the grave. For a year past he had been seeking relief at the hands of some of our most distinguished men, and when we asked him what remedies he had been taking, he answered that it would be difficult to say what he had not taken. While he was in Canada his physician had made use of general faradization, but with no appreciable result.

When he came under our care we made use of general faradization, both during a paroxysm and when he was free from pain; but the faradic current seemed to be wholly inoperative.

We then made use of a strong galvanic current, placing the positive pole on the back of the neck, just above the seventh cervical vertebra, and applying the negative over the region of the stomach, in order to affect the solar plexus and pneumogastric.

The application seemed to refresh him, and relieved in a marked degree the vague, dull aching which was always present in the interval between the paroxysms. It so increased his appetite that in a few hours he ate a hearty meal, something which he had not done before in two years.

At the usual hour on the following night the paroxysm returned, but was most singularly located between the shoulders, while the stomach was almost entirely free from pain. After the second application the pain resumed its seat in the stomach, but was not of such a severe character as formerly. Believing that the tonic properties of the electricity would enable him to do without the opium more readily than on previous occasions, we advised that it be discontinued. It was a most difficult undertaking; but, for three weeks, until he was imperatively called South, not a particle passed his lips. He received in all but six applications of the galvanic current, and although the cure was by no means complete, yet the relief he experienced was positive and most gratifying.

His appetite remained permanently better, and digestion was performed with more comfort and rapidity. The regularity of the paroxysms was broken, and their severity ameliorated.

The wild, wandering look of distress, which was ever stamped upon his features, gave place to a calmer and more hopeful expression. Unfortunately, circumstances rendered it impossible for him to remain longer at the North; but sufficient benefit had been derived, during the brief time that he was under our care, to render it probable that still further amelioration of his remarkable symptoms would have been obtained by a persistent use of the galvanic stream. We were the more hopeful, from the fact that on a previous occasion we had treated successfully, by general electrization with the faradic current, a lady suffering from this form of neuralgia, but of a less aggravated character.

So far as regards the treatment of this case, the point of particular interest lies in the fact that the galvanic current was of value while the faradic was wholly inoperative. By the use of the galvanic current the pain was immediately relieved, the digestion was strengthened, and the appetite sharpened.

Angina pectoris—Temporary, but no permanent benefit.

CASE 47.—Mr. R., a gentleman in the prime of life, had suffered for several years from severe pain in the chest and leg. During a paroxysm he was much oppressed for breath, and this feeling of oppression he could easily bring on, even by moderate exercise in walking. It was a singular fact that he could exercise violently with his dumb-bells without experiencing any inconvenience. He had been previously laid up on two or three different occasions by attacks of gout, which finally left him in this condition. He was evidently affected with *angina pectoris*, and because of this gouty diathesis but little encouragement was given. He persevered in the treatment for over a month, during which time we treated him by both the faradic and galvanic currents. He sometimes experienced marked temporary benefit after a very powerful application of the faradic current, but the pain and the oppression in his breathing invariably recurred. We were able to afford no permanent relief. Galvanization of the pneumogastric was not tried.

Sciatica of nine months' standing, with anæsthesia—Relief of symptoms by four sittings of general faradization.

CASE 48.—Mrs. M., aged 45, had suffered for nine months, almost constantly, from a dull pain along the course of the sciatic nerve. At times an acute paroxysm would occur, causing fearful distress. She had been treated by cinchona, iron, and ungt. veratriæ, and, as she thought, with some benefit. The disease was, however, by no means subdued, nor was there much permanent amelioration of pain. She complained of a feeling of numbness all over the calf of the leg, and at times she was quite insensible, in that part, to ordinary impressions. The first application of the faradic current was exceedingly gentle, and as soon as the séance was ended she expressed herself as feeling a sense of general relief. During the course of twelve days four applications were given, resulting not only in complete amelioration of all neuralgic pain, but also in restoration of the anæsthetic part to its normal sensibility. After the last visit the joint of the great toe of the affected limb enlarged and became quite painful, but subsided to its usual size after a few applications.

Sciatica is sometimes very obstinate.

Neuralgia of left side of the head—Treatment by localized faradization—Relief.

CASE 49.—Mr. L., aged 28, referred to us by Dr. Samuel T. Hubbard, had suffered for four weeks from an acute attack of neuralgia. The pain was confined almost exclusively to the left side of the head, and was of such a severe character that he was able to obtain but little sleep, either night or day. The neck became quite stiff, so that he could with difficulty move the head from side to side. So constantly and severely had he suffered, that nearly all the functions of the body were disturbed. The appetite was much impaired, digestion was performed slowly and painfully, the bowels were unusually constipated, and the whole nervous system was so completely unstrung, that the patient was unfitted for any mental or bodily effort. It is proper to state that from the beginning of the attack he had received the most judicious and careful medical treatment, but with very unsatisfactory results. A mere temporary amelioration of his symptoms was all the relief that was afforded by internal medication or external application.

A minute history of the case gave no clue to the probable or even possible cause of the attack.

There was no hereditary tendency or constitutional taint to account for the affection. The pain seized him suddenly, after no exposure or dissipation. The affected part was but little more than usually sensitive to the touch alone, but an exceedingly mild faradic current caused excessive pain. The current was made less intense, so that it produced no discomfort, and the application continued for about ten minutes.

At its close the patient expressed himself as entirely relieved of the acute pain that distressed him.

Galvanic belts and disks for the treatment of neuralgia have been recommended by Hiffelsheim. He applies the belts—either Pulvermacher's or Davie's—moistened with vinegar, to the painful locality, and allows them to remain there for days, weeks, and even months. Although Hiffelsheim reports some good results from these applications, yet it must be admitted that tnere is as yet no sufficient, reliable evidence that they have succeeded where galvanization or faradization has failed, or that they have any positive advantage whatever, except, perhaps, for those who are so situated that they cannot receive ordinary treatment.*

The objections to and disadvantages of this method of treatment in neuralgia, as in all other affections for which it has been so widely employed, are these:—

1. The current which they generate is very feeble and inconstant, and probably does not, except under peculiarly favorable circumstances, penetrate far beneath the epidermis.

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* The therapeutic results obtained by wearing galvanic chains, belts, disks, soles, girdles, &c., must depend on the manner of their construction and application. Many of those which are sold in the stores and extensively and indiscriminately used by the laity, are so arranged that the feeble currents which they may generate fail to make a circuit through the body, and recombine in the metals themselves.

2. They can only be used locally. Many of the symptoms for which they are used are of a constitutional character, and can only be permanently dispelled by measures calculated to affect the whole system.

3. They are usually, and sometimes necessarily, applied to the seat of the pain rather than to the seat of the disease. In galvanization and faradization for local neuralgia, it is found that the best results are obtained by treating the seat of the disease.

4. They sometimes cause ulcers that leave permanent cicatrices.

The benefit that is derived from them is probably due in part to their influence on the imagination.

These arguments against the use of galvanic belts would be valueless, if experience could demonstrate from their use any great utility or any very positive advantage.

It is not impossible that, in future improvements in the construction of these belts and chains, and more scientific experiments in their use, we may develop advantages from them which they have thus far failed to exhibit, and may accord to them a position in electro-therapeutics to which, from the results of the past, they are not entitled.

The fact that they have thus far been used almost exclusively by the laity, and have been made the theme of noisy advertisements, so far from discouraging, should rather stimulate men of science who have any faith in their efficacy to rigidly investigate and interpret their claims to a position among the appliances of electro-therapeutics.

Those, however, who experiment with these contrivances, should remember that the mechanically irritating effects of metallic bands applied to the tender skin are not inconsiderable, and that the therapeutic results which appear to follow their application may not unlikely be due wholly, or in part, to *counter-irritation.*

(*For further remarks on this subject, see Myalgia.*)

Facial neuralgia of several years' standing—Treatment by galvanization and faradization—No benefit.

Case 50.—In the fall of 1866 we were called upon to examine the case of a

widow lady, who had for several years been the victim of most excruciating pains of the fifth pair. Previous to the first attack she had always enjoyed a good degree of health, and notwithstanding her almost constant and severe sufferings, she still retained all her strength and flesh. At first the pain was located in the superior maxillary branch of the 5th pair, and for a time was mild in character. In the course of a few months, however, the paroxysms became more frequent and severe, and the ophthalmic as well as the inferior maxillary branch began to suffer. When presented for treatment by electrization, the patient represented that at no time in her waking moments was she entirely free from pain. Paroxysms of intense agony were excited many times during the day by a variety of causes. Any sudden excitement, as of anger or fear, a start or jar, prolonged effort in conversation, and the act of eating, were sufficient to produce them. In fact, so excitable had the affected nerves become, that it was impossible for her to eat with comfort anything but the softest food.

The eye was watery, and on the slightest cause became inflamed; while over the mucous surfaces of the cheek and nose a very annoying feeling of numbness was frequently present. A brief course of treatment convinced us that we could do but little to relieve the suffering of our patient, and although she has since consulted other physicians and tried many remedies, she has received no benefit.

Neuralgia of the forehead of eight months' standing—Treatment by local faradization—Recovery after eight applications.

CASE 51.—A laboring man, aged 45, stated that for the last eight months he had been subject to very severe neuralgic pains that were located over the frontal region.

They occurred periodically, sometimes two, and then again three days passing without a return of the attack. The paroxysms of pain generally lasted for about two hours; but occasionally a whole day passed without any relief. In the latter case the patient did not, as usual, perfectly recover before the next paroxysm, but was annoyed by a constant though slight vertigo. An application of the faradic current was made during the interval between the paroxysms. Two days later the patient presented himself, while suffering from an attack of considerable severity. An application, given as before, lulled the pain to a great extent, and for nearly a week he had no return of it. When it returned the pain was much less acute than formerly. The patient was under observation some three weeks, and received seven or eight applications.

During the last ten days of treatment he suffered no relapse, and was discharged as cured.

The character of the pain and the history of the case and treatment declared for a peripheral seat of the disease.

Mild cases of the so-called peripheral neuralgia are of everyday occurrence, and readily yield to treatment or recover spontaneously.

Others, of a more severe and persistent type, are frequently met with, but are successfully treated by the internal administration of quinine, valerianate of zinc, colchicum, etc., as well as by a variety of local applications. Not unfrequently, however, all the ordinary internal remedies and external appliances prove unavailing. It is in such instances, well illustrated by the following case, that electrization is frequently followed by admirable results.

Severe neuralgia of the fifth pair, of four years' standing—Recovery under general faradization.

CASE 52.—Mr. M., aged 65, a man who had enjoyed most excellent health all his life, stated that he suffered acutely and almost constantly during the day from a persistent and aggravated form of facial neuralgia. When in perfect repose, as in the night after retiring, he suffered but little and slept soundly; but whenever he attempted to converse, or to eat, or in any way to use his jaw, a sharp shooting pain of a most intense character, and attended by an increased flow of saliva, was excited along the course of the fifth pair. *The action of the direct rays of the sun invariably produced the same result.* Some four years previously, while at dinner, he first felt an acute pricking pain under the ear. These attacks annoyed him occasionally, but in the course of twelve months they became more frequent and severe, and for the last two and a half years he had suffered as stated above. The first application of the faradic current gave him immediate relief. The paroxysms of pain were excited less readily, were less severe, and not so prolonged. He continued to improve under the influence of three more applications; but in order to hasten the cure, a galvanic current from eight cells of Stöhrer's battery was substituted. The effect was temporarily disastrous. The paroxysms of pain returned with all their former severity.

Fortunately, however, a few gentle applications of the faradic current repaired the evil produced in this case by the galvanic, and *in less than six weeks* from the commencement of treatment, and after having received fifteen applications, he had so far recovered as to be unconscious of pain dnring the ordinary efforts of talking and eating.

REFLEX NEURALGIA.

The term reflex, as applied to paralysis, is at once common and suggestive. In the same way it is applicable to neuralgia.

As in children paralysis frequently follows the irritation of teething or dysentery, and in older persons that of urinary disease, so neuralgia of distant parts may result from uterine and other disorders. Neuralgia of the fifth pair, caused by a carious or false tooth, is a common and well-known reflex result of mechanical irritation. The treatment of reflex neuralgia is by no means so empirical as that of the peripheral variety. If a carious tooth is at the root of the evil it must be removed.

If the cause can be traced to uterine disease, the skill of the gynecologist is called for. Occasionally electrization, through its power of subduing local irritation or inflammation, effectually relieves the remote neuralgic pain, of which the irritation or inflammation is the cause.

Neuralgia of left leg, apparently proceeding from ovary—Recovery.

CASE 53.—In the case of a young lady who had suffered for several months from the most severe neuralgic pains down the left leg, tactile examination revealed very marked tenderness to pressure in the left ovarian region. No other portion of the body was especially susceptible to the touch. It is proper to state that the patient was not at all hysterical, that exercise aggravated the pain, and that the neuralgia of the limb was in proportion to the tenderness over the ovary. She was immediately relieved by localized faradization, and completely recovered in the course of six weeks, after having received twelve applications.

CHAPTER XXIII.

ANÆSTHESIA.

Anæsthesia is derived from *α*, privative, and *αἰσθάνομαι*, to perceive, and therefore literally signifies a deprivation of sensation. It is a symptom of some organic or functional disease of the central or peripheral nervous system. The kinds of anæsthesia are as various as are the nerve ramifications, and the symptoms that accompany it are modified by the locality and causation of the disease. All forms of anæsthesia, as of paralysis of motion, may be classified under these four general divisions: Constitutional, central, peripheral, and reflex.

In the study of anæsthesia, it is of prime importance to distinguish between the cases of a central and peripheral origin. This question is to be determined by the *history of the case, by the complications, and by the extent of the disease.*

Among the constitutional causes of anæsthesia are the poisons of lead, mercury, arsenic; certain diseases, such as syphilis, diphtheria, etc., anæmia, neurasthenia, and hysteria. We sometimes meet with slight anæsthesia of the right or left side of the body, of an upper or a lower extremity, or more frequently still, of a portion of the foot, or of one or more of the fingers, in patients who complain of no other symptom of the disease. Young persons who have weakened their growing constitutions by long confinement in stores or at school, and adults who have reduced themselves into a nervous condition by worry and excitement, are not unfrequently attacked either suddenly or gradually by this form of anæsthesia, without experiencing any other coïncident symptoms whatever. The interesting point in regard to such cases is, that they are oftentimes easily relieved and cured by appropriate treatment, without experiencing any hemiplegic or paraplegic attack, of which such anæsthesia is often the precursor.

And yet it should ever be borne in mind that anæsthesia may be, and frequently is, the chief premonitory symptom of serious organic disease. It may be the only forerunner of affections of the cerebrum and of the spinal cord, as well as of the various nerve ramifications. Thus hemiplegia, locomotor ataxy, meningitis, myelitis, may all be preceded by anæsthesia of a limited portion of a limb, of a hand or foot, or of a finger or toe, or of some small localized spot in the face or on the head. Anæsthesia is a very frequent accompaniment of all the different forms of paralysis of motion in all their stages.

Among the more frequent central causes, are lesions or irritable conditions of the brain or of the spinal cord; and indeed, whatever disturbs the function of the nerve-centres. Among the peripheral causes may be mentioned local pressure on, or injuries to, the nerve, such as may be caused by tumors, aneurisms, wounds, inflammation of the sheath of the nerve, or of the tissues that surround it.

There are four kinds of sensibility, all of which may become diminished by disease :—

1. *Tactile sensibility.*—This is the form which is most frequent, and best appreciated. Diminution or loss of this sense is usually known as *anæsthesia.*
2. *Sensibility to temperature*—heat and cold.
3. *Sense of pressure or weight.*
4. *Sense of pain.*—This is quite distinct from tactile sensibility, with which, on superficial observation, it is often confounded. The loss of this sense is called *analgesia.* These different kinds of sensibility may be very unequally affected by disease. One form may be entirely destroyed, while the others remain intact. Thus, while tactile sensibility is perfect, the prick of a needle, when thrust into the flesh, is not felt. In such cases there is *analgesia,* but not *anæsthesia.*

The diagnosis of anæsthesia, except in very delicate cases, is sufficiently easy.

The degree of normal sensibility to tactile impressions varies widely in different parts of the body. It is necessary to bear this fact in mind, and to make experimental trials on persons in health, in order to arrive at correct conclusions in cases of disease.

The use of the compasses, according to the directions of Dr. Weber,* will enable one to determine in a very accurate manner the condition of the sensory functions in health and disease.

Thus, when the two points of a pair of compasses are placed upon the inner surface of the last phalanx of the finger, they need to be separated but one line in order to give two impressions, while, in the middle of the thigh, the points of the compasses need to be distant from each other some fifteen to twenty-five lines in order that two impressions may be received.

Sensation in the tip of the tongue is more acute than in any other part of that organ, for two impressions are received when the points of the compasses are separated by only half a line ; and it will be found that, in the face, this sense of acuteness diminishes as we recede from the mesial line.

Electro-diagnosis.—There is another method of determining the relative sensitiveness of the two sides of the body that we have found very convenient and reliable, and sufficiently delicate except for those cases when the anæsthesia has extended over the entire system. This method is based on the observed fact that modifications of sensibility are indicated by the electric currents. It consists in the application of the electric current by means of a brass ball, or other metallic electrode, attached to one of the poles of a faradic apparatus. The other pole of the apparatus may be placed at the feet of the patient, or at the coccyx, or at any indifferent point, as may be convenient.

Different points of the body, on both sides, are *alternately* touched with the brass ball, perfectly dry, very lightly, and with a mild current. In order to test the sense of pain, the ball should be covered with a moist sponge, so that the current may penetrate the epidermis. In this way a very slight difference of sensibility, especially of the upper and lower extremities, can readily be detected. By gradually increasing the power of the current up to the point of endurance, the extent of the anæsthesia can be ascertained with tolerable accuracy. One great advantage of this method is, that the same apparatus with which we treat the disease can be used to diagnosticate it, and to mark the progress from day to day.

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* De pulsu, resorptione, auditu et tactu, annotationes anatomicæ et physiologicæ. Lipsiæ, 1834.

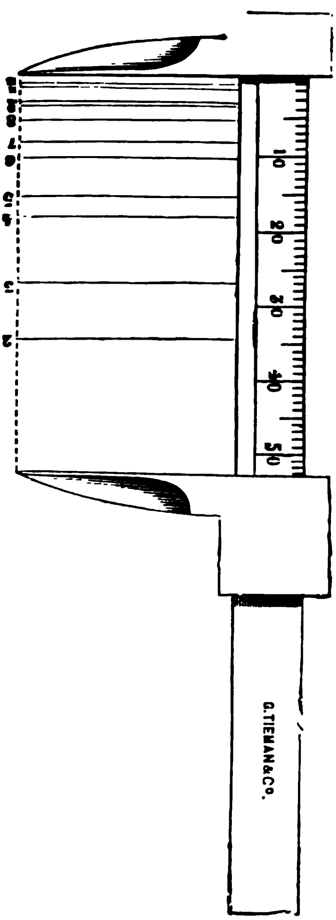

FIG. 56.—Æsthesiometer.

The æsthesiometer (αἴσθησις, sensibility, and μέτρον, measure) was first introduced into medical practice by Brown-Séquard, in 1849. At first he used a pair of compasses, but in 1858 he devised the following æsthesiometer.

This is a rule, graduated to millimetres. It is provided with two points — one fixed, the other movable. The movable point indicates the distance at which the points can be distinguished. In using it, the rule must be held parallel to the surface.

In using the æsthesiometer the following rules should be observed :—

1. Cover the points with bits of cork.
2. Apply the points simultaneously.
3. Do not allow the patient to see the points when they are applied.
4. Make the application first on a healthy part.

Eulenburg, of Berlin, has devised an instrument for determining the *sense of pressure*, to which he has given the name *baræsthesiometer*. Previously, the sense of pressure had been obtained by means of *weights*—a method at once inconvenient and unreliable.

Eulenburg's instrument consists of a spring in a German-silver tube, which is connected with an indicator. The end of the spring is applied to the skin by rubber disks of three sizes. The increase of sensation in any given case is measured by the ratio of the additional stimulus to the original stimulus. The absolute amount of the latter is of little consequence.*

In this instrument the highest degree of pressure is thirty-one grammes—nearly one pound.

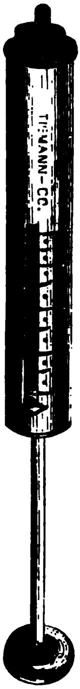

FIG. 57.—Piesmeter.

Shortly after Eulenberg had devised his baræsthesiometer, and before we had any knowledge of the principle on which his apparatus was constructed, we had conceived the idea that the principle of the inverted scales might be made available for measuring the sense of pressure, and had contrived the simple instrument represented in the accompanying cut. To this we gave the name *piesmeter* (πιεσμός, pressure, and μέτρον, measure). This is to be used in the same way and for the same purpose as the contrivance of Eulenberg.

This instrument also consists of a spring in a German-silver tube. The spring is pressed by a rod, on the end of which is a hard rubber disk ⅛ of an inch in diameter; on the tube is a scale, which is graduated sufficiently for most practical purposes, though it may be indefinitely extended and refined.

The sense of pressure is strongest on the forehead, tongue, and cheek; next in order come the fingers, back of hand, fore-arm, and arm; then the anterior portion of the thigh and leg, back of foot, and toes. The least sensitive portions are the back of thigh and leg. On comparison, the relative sensitiveness of different parts of the body to faradization, with the relative acuteness of the sense of the pressure, exhibits a remarkable coincidence. (See Electro-therapeutical Anatomy, pp. 255, 256.)

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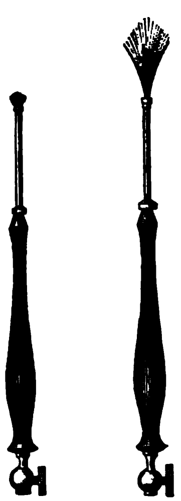
* Journal of Psychological Medicine, No. 3, vol. 4, 1870, p. 622.

We have found diminution of sensibility to pressure in ***locomotor ataxy and in hemiplegia.*** In some hysterical conditions it is exalted.

Eulenberg has found a decided diminution of the sense of pressure in cases where the sensibility to pain and to electricity were both slightly affected, and when the sense of temperature was natural.*

Treatment.—Either general or localized faradization is indicated, according to the condition of the patient. When the anæsthesia is very limited in its extent, and the general health of the patient is otherwise good, localized electrization is preferable to general, because more convenient. As a matter of fact, however, very many anæsthetic patients, whatever may be the cause on which their symptoms depend, are more or less debilitated, and are benefited by the constitutional tonic effects of general electrization. In cases of anæsthesia that are dependent on lesion of the central nervous system, galvanization of the sympathetic or through the central nervous system is sometimes indicated. Obstinate cases of a localized character are well treated by the electric brush. Sometimes this severe method of treatment reveals sensations that other and milder tests fail to discover.



Closed. Open.

FIG. 58.—Electric Brush.

The *prognosis* in anæsthesia, waiving for the moment all questions of causation or pathology, is usually very favorable, and beyond comparison more favorable than that of paralysis of motion.

One reason for this difference is that anæsthesia is an earlier symptom of organic disease of the nervous system than motor paralysis, and is therefore sooner treated. But we continually observe, even when the two conditions co-exist, as is so frequently the case in central, spinal, and peripheral paralysis, that the anæsthesia yields much sooner and far surer than the paralysis of motion.

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* Drs. Mitchell, Morehouse, and Keene made the same observations in cases traumatic paralysis.—*Gunshot Wounds and other Injuries of Nerves*, p. 18.

The discussion of the interesting physiological questions suggested by these observations, though somewhat enticing and suggestive, does not come within the scope of the present work. Of 29 cases of anæsthesia of all kinds that we have treated, 14 recovered, 12 approximately recovered, 1 was decidedly benefited, and in 2 cases the results were unknown.

Anæsthesia of anterior region of right thigh, of traumatic origin, of ten years' standing—Permanent recovery under faradization.

CASE 54.—Mr. H., a stout, vigorous man, aged 29 years, was sent to us by Dr. H. Gregory, of Harlem, to be treated for anæsthesia (which had annoyed him for many years) of the anterior portion of the right thigh. The only possible cause to which we could refer the symptoms was an incised wound that he had received in the thigh, near the great trochanter, some ten years previously.

The patient could not positively state that the paralysis of sensation immediately followed the injury, since the anæsthesia was not so noticeable as at a later date. The part had become so insensible to ordinary impressions, that it was necessary to separate the points of a pair of compasses some 45 to 50 lines, before two impressions were received. The pricking of a pin caused no sensation, and even when the point penetrated several lines beneath the surface, no pain was experienced.

Dissipation in eating and drinking, unusual exercise and loss of sleep, invariably aggravated the disorder. The first application of the faradic current—made down the spine and to the affected limb—very markedly relieved the anæsthesia, and after the third application the limb was restored to its normal sensibility. At the fourth visit he complained that the part had partially relapsed into its former anæsthetic condition, but accounted for it from the fact that he had spent most of the previous night at a social gathering.

An application again relieved the anæsthesia. We found, as usual in all cases of anæsthesia, that, as the limb progressed toward a cure, it became more and more sensitive to the influence of the current.

After receiving ten applications the limb was again restored to its normal sensibility, although occasionally, after unusual exertion and loss of sleep, it became somewhat anæsthetic.

In the case of this gentleman, the wound before referred to was over the course of the external cutaneous nerve, after it passed beneath Poupart's ligament. Now, anæsthesia of the peripheral cutaneous nerves follows most frequently a solution of continuity of those nerves, and it is not at all probable that a part rendered anæsthetic by the complete division of the nerve-fibres supplying it, could ever regain its normal sensibility by any method of treatment.

But in this case the beneficial results that followed treatment by electrization were due, doubtless, to the fact that the nerve had suffered merely from contusion and not division. In this connection, however, it may be well to say that it has been demonstrated by Dieffenbach,* that anæsthesia caused by division of nerve-fibres is, in some instances, relieved by the reparative processes of Nature.

Numbness of left hand and foot; general debility—Recovery under general faradization.

CASE 55.—Mr. E. R, aged 48, began to experience a feeling of numbness in the left hand about two months before we saw him. It gradually extended to the left leg and foot, until April 20, 1867, when he applied to us for treatment. His general health was neither robust nor greatly impaired.

He was actively engaged in financial matters, requiring more than ordinary attention, and which brought with it excessive care and anxiety.

The affected limbs were somewhat below the normal temperature and the anæsthesia was especially noticeable when the feet were brought in contact with any cold substance. He exhibited some awkwardness in locomotion, since he was not sure when the paralyzed member reached the ground.

We made use of general faradization, only using the ascending in preference to the descending current. The disease yielded with remarkable readiness to the applications, and after six visits, sensation in the leg and arm was perfect.

Occasionally the application of electricity, either the faradic or galvanic current, is followed by a peculiar sensation of a reflex character in one or more parts of the body, described as similar to that of the passage of the current through the system. In such cases there may be incipient or forming disease, or a morbidly irritable condition of the central nervous system.

Numbness of right arm and leg—Peculiar result of faradization.

CASE 56.—Mr. H., aged 34, of slight build and nervous temperament, had been troubled for some time by considerable numbness of the right arm and leg. He had been under the care of Dr. H. Gregory, who recommended the use of electricity. We gave the patient three general applications of the faradic current, and succeeded in entirely dissipating this feeling of numbness.

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* Romberg on Nervous Diseases. Sieveking's translations, vol. i., p. 208.

Ater the treatment he suffered from slight nervous prostration, and subsequently he stated that, every time he made a slight motion of his head downward, and a little to one side, a *peculiar tingling sensation was always felt down the leg to the foot.* This symptom continued to annoy him for several weeks, when it removed its seat to the arm, and in a short time disappeared altogether.

Hysterical hyperæsthesia is much more commonly noticed with us than anæsthesia.

The latter condition is without doubt occasionally overlooked, and again may sometimes be feigned.

Hysterical anæsthesia—Diminution of temperature during the attacks—Great insensibility—Gradual improvement and final recovery under general faradization.

CASE 57.—Mrs. S., aged 33, was subject to frequent attacks of hysteria, with intense melancholy. She suffered also from general neuralgic attacks, which were followed by almost complete anæsthesia — commencing at the fingers of either hand, extending up to the arms, the shoulders, and face, and finally involving the tongue, so that her speech was only in broken utterances.

About the finger-nails the skin assumed a dull leaden color. The pulse was almost imperceptible, and the temperature of the affected parts was considerably below the normal. Insensibility to painful impressions, which always preceded the loss of the sense of touch, was at first incomplete, but gradually increased. During the attack her memory always became much impaired, so that she was often unable to call to mind the names most dear to her.

The paroxysms lasted from twenty minutes to half an hour, and were followed by a severe headache, while a considerable numbness of the arms and hands remained for several days. Carbonate of ammonia seemed to relieve her more quickly than any other internal remedy, but nothing she had ever tried had been of any very permanent benefit. An application of the faradic current, made to the parts affected during a paroxysm, always shortened the attack; although, while the anæsthesia lasted, the fingers, arms, face, and tongue, were insensible to the influence of a current of considerable power.

Treatment by general electrization was continued during the interval between the paroxysms, resulting in a diminution in the severity of each succeeding attack, until in a few months they ceased to trouble her.

Anæsthesia of left side of face, extending to left nostril and internal surface of cheek, and complicated with paralysis of motion—Improvement and recovery under faradization.

CASE 58.—Miss A. G., an unmarried woman, aged 28, applied for treatment for cutaneous anæsthesia of the left side of the face. She was employed in a bookbindery, and her daily labor extended over a period of from twelve to fourteen hours. As a natural consequence, her general health had become somewhat impaired.

Her menstrual function was, however, performed regularly; and, although her digestion seemed to be vigorous, she was nervous and anæmic.

She gave the following account of herself: Some six mouths previously, she noticed, at the close of a day of hard labor, and after exposure to a cold biting wind, a slight feeling of numbness in the right side of the face. This numbness rapidly increased, until in a short time the anæsthesia was complete. On examining the face it was found that the mouth was drawn somewhat over to the right side. There was slight ptosis of the left eyelid, and the left cheek was flaccid. The want of expression was quite marked on the affected side—and contrasted strongly with the right side when she laughed, or entered into conversation. She was entirely insensible to ordinary impressions on the left side of the face, and the anæsthesia extended to the *left nostril and the internal* surface of the cheek.

The sensation and movement of the tongue, and the power of taste, were unimpaired. Local applications of the faradic current were given every day or two, but for some little time no impression seemed to be made on the diseased nerve.

It was only after treatment had been continued two weeks, and some eight applications had been given, that any sensitiveness to the current was manifest along the course of the fifth pair. The improvement, however, from this time, although slow, was constant.

In this case the rule that the anæsthesia improves more rapidly than the paralysis of motion was reversed.

The anæsthesia improved but little until the face assumed its natural proportions, when, in a short time, the normal sensation entirely returned. The treatment was continued during two months. In most cases of anæsthesia of the trigeminus, related by Romberg, the loss of sensation was so marked that deep pricking with a needle caused no pain, while in this case the anæsthesia was limited to the skin and mucous membrane. Anæsthesia of the fifth pair of nerves may be peripheral or central; in the latter case there is coincident paralysis of other nerves of motion and sensation, and hemiplegia, more or less complete, is often present.

The diagnostic symptoms of this variety of paralysis differ, according as the seat of the disease is located in the course of the various ramifications of the fifth pair, after it leaves the sphenoid bone, or in the Casserian ganglion, or at the base of the brain.

These diagnostic symptoms of the seat of the disorder or lesion are summed up by Romberg in the four following propositions :—

1. The more the anæsthesia is confined to single filaments of the trigeminus, the more peripheral the seat of the cause will be found to be.

2. If the loss of sensation affects a portion of the facial surface, together with the corresponding facial cavity, the disease may be assumed to involve the sensory fibres of the fifth pair, before they separate to be distributed to their respective destinations ; in other words, a main division must be affected before or after its passage through the cranium.

3. When the entire sensory tract of the fifth nerve has lost its sensation, and there are at the same time derangements of the nutritive functions in the affected parts, the Casserian ganglion, or the nerve in its immediate vicinity, is the seat of the disease.

4. If the anæsthesia of the fifth nerve is complicated with disturbed functions of adjoining cerebral nerves, it may be assumed that the cause is seated at the base of the brain.

The case under consideration, doubtless, comes under the second proposition, and as the nasal nerves had lost their function, while the left half of the tongue was sensible to sensory and gustatory impressions, and the surface of the eyeball was unaffected, the second branch only of the fifth pair was chiefly affected. Althaus * records a striking case of complete anæsthesia of the fifth pair that was much benefited by galvanization, the positive pole being placed at the nape of the neck, and the negative passed along the peripheral nerves.

Anæsthesia of left side of the body, with dyspepsia—Nervous exhaustion—Improvement under general faradization.

CASE 59.—Mrs. J., aged 60, was referred to us by Dr. Gurdon Buck, June 18, 1868. The symptoms of which she complained, and for which she desired treatment, were mainly those of debility. She was dyspeptic, nervous, and incapable of much physical exertion. There was numbness of the left hand and foot.

Electric Examination.—Very profound anæsthesia of the whole left side of the body. *Over the left hypochondriac region the anæsthesia and analgesia*

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* Op. cit. pp. 137, 537.

were so marked that the whole strength of the faradic current applied by a metallic electrode caused no pain and no sensation.

The numbness had been of two years' standing, and was probably due to some morbid condition of the right side of the brain.

General faradization (with strong and protracted applications) was administered every other day for one month, with gradual but positive improvement. There was relief of the dyspepsia, and very considerable increase of strength. *The anæsthesia was reduced to a minimum.*

The patient was afterwards debilitated by the extreme heat of the summer of 1868; since that time we have heard nothing from her.

The above case illustrates that even those who are advanced in years, and in a condition of debility, may sometimes receive with benefit very powerful applications.

CHAPTER XXIV.

PARALYSIS.

PARALYSIS is a condition for which, from the earliest history of electro-therapeutics, electricity in its different forms has been used more than in any other disease; and not until quite recently has it been demonstrated that there are many other diseases in which the results of electrization are even more rapid and important.

All forms of paralysis, as of neuralgia, may, for the sake of convenience of description of therapeutical indications, be included under one of these four divisions:—

1. Constitutional.
2. Central.
3. Peripheral.
4. Reflex.

Constitutional Paralysis.—This term is applied to those paralyses which arise from some blood-poison or constitutional degeneration.

Among the more common causes of this variety of paralysis may be mentioned the poisons of certain diseases, as gout, rheumatism, syphilis, etc.; mineral poisons, as lead and opium, etc. Constitutional paralysis may be subdivided also into central and peripheral, according as the morbid poison fixes itself in the central or peripheral nervous system.

Rheumatic Paralysis.—In this condition electrization is of considerable value. In those severe cases of chronic rheumatism where the poison has so affected the theca of the nerve or the tendons that hideous deformities and complete loss of power are produced, no method of treatment avails anything. In the partial but persistent paralysis that occasionally follows subacute muscular rheumatism, electrization has in our hands proved exceedingly efficacious. The muscles most frequently affected by rheumatic paralysis are the deltoid and trapezius (in consequence of which it becomes impossible or difficult to lift the arm from the side), the extensor muscles of the fore-arm, the muscles of the lower extremities, and occasionally the inter-ossei and lumbricales muscles.

The *electro-muscular contractility* in recent cases is normal; in long-standing cases, diminished.

In this, as in other forms of paralysis, atrophy of the muscular tissue occurs after a certain length of time. It is extremely important to begin treatment before the muscles become thus affected. In cases of rheumatic paralysis, where the invasion has been sudden and the pain considerable, electric excitation produces pain; but where the invasion has been more gradual and unattended by pain, electric excitation causes very little, if any sensation.

Rheumatic paralysis of deltoid, of several months' standing—Recovery under general and localized faradization.

CASE 60.—A patient, a young lady aged 23, had been unable to raise her hand from her side for several months. The access of the rheumatism was gradual, and unattended by acute pain, excepting when pressure was made over the affected muscle, or when she attempted to raise the arm. An application of the faradic current caused pain only when it was sufficiently intense to produce contractions.

The muscle rapidly became less sensitive to the influence of the current, and gradually regained its lost power. The restoration of strength was complete in two weeks.

We have treated quite a number of cases of rheumatic paralysis of the deltoid, the trapezius, and of the lower extremities, and invariably with the most satisfactory results. Electrization is always indicated in this condition, and few cases, doubtless, would fail to recover under its influence.

Syphilitic Paralysis.—Syphilitic nervous affections may exist either with or without appreciable structural change. Paralysis or neuralgia which results from secondary syphilis may derive some benefit from electrization; but when either of these two conditions are associated with the tertiary form, they are generally beyond the reach of remedies.

In the latter case the paralysis or neuralgia may usually be ascribed to an anatomical lesion or a morbid growth.

Lead Paralysis.—In slow poisoning by lead the metal becomes diffused throughout the whole system, and exerts its influence, though in an unequal degree, on every nerve and organ.

As is well known, however, the upper extremities are most frequently affected by paralysis (more or less complete). The muscles usually affected are the extensors of the hands and fingers, so that they hang down by their own weight. It is probable that these muscles are chiefly affected in this disease as in hemiplegia, because they are weaker and operate at a great mechanical disadvantage. Dr. Hitzig, of Berlin, who has specially studied this subject, states :—

"That the peculiar predisposition of certain muscles to lead paralysis manifests itself through the various conditions of the veins of the muscles."*

M. Tanquerel des Planches saw, amongst 113 cases of lead palsy, 93 cases of palsy of the arms, 14 of the lower extremities, and 6 of general paralysis. The electro-*muscular contractility* of the affected part, in this form of paralysis, is always diminished; and frequently it is entirely lost, even in cases where there is little or no atrophy of the muscles. The electro-muscular sensibility is usually unimpaired. Diplegic contractions may appear in this disease. According to Hitzig, mobility in cases of lead poisoning is lost before electric contractility.

If the electro-muscular contractility is completely lost, it is better to apply a mild galvanic current to the paralyzed part for a few minutes before the faradic is made use of. The latter current should be used daily, and not longer than ten or fifteen minutes at each sitting. As soon as the slightest contractions are produced by the faradic current, the galvanic may be discontinued.

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* The same observer further declares lead poisoning may be caused by the manufacture of curled hair, especially where poor materials are used, and that lead may remain in the system a long time before the symptoms of poisoning appear.

Paralysis from Opium Poisoning.—The tendency of the action of opium on the system is to paralyze.

Under its influence all the internal secretions diminish. It affects the nervous system and all its functions—first exciting and then depressing their activity until unconsciousness, and then death supervenes. In desperate cases of poisoning by opium, electricity has been repeatedly used with success. The faradic current should be employed.

The method of artificial respiration may be used (see chapter on *Artificial Respiration.*)

After recovering consciousness from severe poisoning by opium the various limbs of the body are occasionally left in a permanently paralyzed condition that persistently resists all the efforts of nature and medicine. Two such cases have fallen under our observation.

Partial paralysis of upper and lower limbs, caused by an over-dose of opium. Improvement under general faradization.

CASE 61.—A little boy, some eight years of age, was presented to us suffering from partial paralysis of the lower limbs, and, in a less degree, of both arms also. He could walk only with the assistance of another, and then with an uncertain staggering gait.

His legs were remarkably small and cold, his bowels continually constipated, and his general condition feeble. When but three years old, his nurse on one occasion administered to him by mistake a teaspoonful of the tincture of opium.

By persistent efforts only was his life saved; but the shock to his nervous system was so great that, for one year after, both legs were completely paralyzed. Finally he regained a portion of strength, until he reached the condition already described.

The electro-muscular contractility and electro-sensibility not only of the limbs, but of the entire body, was much improved. The boy could bear, without pain, a faradic current of sufficient intensity to prostrate a grown person in ordinary health. The first general application seemed to benefit him.

He felt *lighter and better.* Six subsequent séances increased his appetite, perceptibly augmented his strength, and relieved his constipation. At this time his legs began to feel somewhat warmer, while he was unable to bear a current of as great intensity as before. The patient was under treatment some two months, and received about twenty-five applications. The temperature of his legs, and of his whole body, had very decidedly improved.

His legs had grown larger, and when he discontinued treatment his general health was fair, and his gait nearly normal.

Hysterical Paralysis.—The hysterical form of paralysis may be said to be not only constitutional, but in some cases also reflex.

It is constitutional, because the entire nervous system is degenerated into a condition of abnormal susceptibility. It may be reflex, because its exciting cause proceeds in many cases from the genital system.

Hysterical paralysis is liable to assume the form of general paralysis, paraplegia, hemiplegia; or it may be located in various parts, as the hands, the larynx, and the bladder.

Dr. Briquet met 113 cases of paralysis out of 430 hysterical patients. In 6 cases the paralysis was general; in 46 cases the left arm and leg were affected; in 14 the right arm and leg; in 5 both arms; in 7 the left arm; in 2 the right arm; in 18 both lower limbs; in 4 the left lower limb; in 2 the hands and feet; in 6 the face; in 3 the larynx; and in 2 the diaphragm.* An attack of hysterical paralysis may be accompanied by anæsthesia, numbness, and formication, and as a rule, is of brief duration. Occasionally, however, the attack is persistent, and so long as it continues, it is frequently noticed that other symptoms, which were before quite prominent, disappear altogether.

Electro-Diagnosis.—In this form of paralysis, the electro-muscular contractility in recent cases is unimpaired; in old cases it may be impaired or lost, or the electro-sensibility may be very much blunted. Diplegic contractions sometimes appear in hysteria. The loss of power is usually incomplete, and sooner or later recovery takes place. (See p. 313.)

Treatment.—The disease is constitutional and demands general as well as local treatment. In many instances general electrization promotes rapid recovery; other cases are very rebellious and only improve up to a certain point. The general treatment may be combined with localized galvanization or faradization of the affected part. (For prognosis, see p. 314.)

The following case is an example of its influence in the transient form of this affection:—

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* A System of Medicine. Reynolds, vol. 2, p. 656.

Hysterical paralysis of right arm—Attacks frequently repeated—Immediate relief from localized faradization.

CASE 62.—A young lady, of an excessively nervous organization, was frequently subject to hysterical attacks, when one of her arms (generally the right) always became perfectly anæsthetic and almost powerless. As a rule, her arm remained in this condition about an hour.

On one occasion, immediately after an attack, a powerful faradic current was directed for two minutes through the arm, from the wrist to the shoulder, completely dissipating the anæsthesia and restoring the lost power. Many similar applications, during subsequent attacks, invariably produced the same result.

Hysterical paralysis of left leg, of three months' standing, with impaired circulation and nutrition—Recovery under general faradization with special reference to the affected limb.

CASE 63.—A married lady, aged 29, had suffered excessively from hysteria ever since her marriage, some five years previously. About three months before consulting us, she observed that her left leg was left in a weak condition after an hysterical attack of more than ordinary severity. This weakness gradually increased for a month, until she required the support of a cane. The circulation became impaired, rendering the diseased limb colder than its fellow, and causing slight atrophy. While the applications of the faradic current were directed more especially to the paralyzed member, the whole system was brought under its influence. After each application the circulation in the affected limb was more vigorous, and its strength was temporarily increased. Permanent benefit followed a week of similar treatment, and in less than one month the leg had regained its usual temperature, size, and strength.

General paralysis of an hysterical character, with loss of motion of both the upper and lower limbs, and severe atrophy of the muscles of the upper limbs—Remarkable symptoms—Very great improvement under peripheral and central galvanization.

CASE 64.—Mrs. S., of Staten Island, aged 41, was the most remarkable illustration of the efficacy of galvanization in paralysis that has ever fallen under our observation. The patient first came under our care Sept. 25, 1868. Nine months before she suffered a miscarriage that had left her in a condition of utter helplessness. Both upper and lower limbs were completely paralyzed, the only power remaining being a slight limited movement of the fingers. The hands were permanently extended, the inter-ossei greatly atrophied, and the muscles of the arm and fore-arm were so much shrunken that the circumference of the arm was diminished to the extent of between one and two inches. The lower limbs were absolutely motionless—not a muscle gave even the feeblest response to the will. The muscles of the lower limbs were but little atrophied even below the knee; but the skin presented a peculiar glossy appearance that is associated with greatly impaired nutrition, which has been described by Drs. Mitchell, Morehouse, and Keen.[*] There was, however, no *pain*, which these physicians found to be an invariable accompaniment of glossy skin that resulted from injury to a nerve. The appearance of the skin may be best understood by comparing it to a cicatrized wound. This appearance was most marked below the knees. Both upper and lower limbs were very cold and very sensitive to cold. *There was no loss of power over the bladder or rectum.* Appetite and digestion were good, but there was some dyspnœa. The patient also slept well usually, although compelled to lie constantly on her back, unless she was turned over. The important feature of the case was the remarkably healthful performance of most of the vital functions, conjoined with absolute helplessness. As the little motion of her fingers was not sufficient to enable her to grasp even the lightest object, it was necessary for the nurse to feed her. Daily she was lifted out of bed and placed in an invalid's chair that could be lowered into a horizontal position. To sit up in an ordinary chair was impossible, since the flexion of her limbs caused unbearable pains in the joints.

The brain was usually clear, though the memory had been somewhat impaired. The patient was surprisingly buoyant; but sustained mental exertion, even the reading of a short paragraph, was followed by sensations of weariness.

The patient was of a nervous constitution, had never been capable of great exertion, and for a long time before the attack had complained of numbness, tingling, and other premonitory symptoms.

Electric examination showed, as was expected, absolute loss of electro-muscular contractility, in both the upper and lower limbs, to the faradic current. A strong galvanic current produced feeble contractions in the extensors and flexors of the fore-arms, but none whatever of the muscles of the lower limbs. There was also very great anæsthesia. Analgesia existed in the lower limbs. In the arms, fore-arms, and fingers, there was *excessive hyperæsthesia of the sense of touch, conjoined with decided analgesia.* A tolerably strong current localized in the muscles was not painful, but the slightest touch on the surface was unpleasant. Two important features of the case were *reflex spasms of the muscles of the lower limbs during electrization, and a peculiar sensation through the whole nervous ramification after electrization.* The patient compared it to "waves of sensation" rolling up and down the limbs.[†] This sensation was sometimes felt one or two days after the application.

Taking into consideration all the facts of the case—the completeness of the paralysis, the loss of muscular contractility, the absence of pain in the limbs or in the spine, the absence of any morbid symptoms in the rectum or bladder, or of a feeling of constriction in the abdomen, the absence of spinal tenderness, or of a sensation of pain when ice or hot water were applied to the back, and the various and peculiar behavior under electrization, we concluded that the case was one of a hysterical character.

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[*] Gunshot Wounds and other Injuries of Nerves. 1864, pp. 79, 80.

[†] One of the authors has experienced a precisely similar sensation through the brain, spinal cord, and all the ramifications of the nerves, after an overdose of hasheesh.

The treatment consisted chiefly in general and localized galvanization three times a week. Both methods were used at the same sitting. At first the faradic current was used, but without making any impression on the disease. The first application of the galvanic current took immediate effect. The next day the patient could raise both of her lower limbs six inches from the horizontal, as she lay in her chair. The improvement was permanent and progressive. Another singular feature was that, in spite of her weakness and helplessness, the patient could and did bear with benefit protracted applications. In order to bring the whole body under the influence of the current at one sitting, and at the same time to give the needful attention to the affected muscles and groups of muscles, the sittings were sometimes double the average length.

Improvement in the upper limbs followed improvement in the lower. The extensors and flexors of the arm and fore-arm soon began to resume their contractility under the faradic current.

Jan., 1869, the patient had steadily progressed from day to day. Although healthful contractions were not obtained in the muscles below the knee, even under the galvanic current, yet the skin had a less glossy appearance, and the power of motion had greatly increased.

The improvement in the arms, though at first slow, was subsequently more rapid in the upper than in the lower limbs. By Jan. 1, both the arms and fore-arms had perceptibly enlarged, as was also shown by measurement. The patient could handle light objects, and was beginning, in an awkward way, to feed herself. She could sit in nearly a natural position in her chair, and when well supported could stand for an instant.

Feb. 1, 1869, the treatment was abandoned, because the patient seemed for the time to remain stationary. At that time she had increased in weight to the extent, it is just to estimate, of twenty-five pounds, although the patient was not weighed. She was able to read short paragraphs, and took her book or paper daily.

On account of the weakness of the peronei muscles of the right leg, the foot had all along exhibited a tendency to turn in. This symptom did not improve.

After the treatment was discontinued, the patient still progressed.

When last seen, Aug., 1870, she had gained from thirty to forty pounds in weight, had nearly full use of her arms and hands, which had regained their full size, and was able to step with assistance, and appeared to be prevented from walking alone only by giddiness. She could read for hours at a time without excessive fatigue.

The improvement in the last few months had been greatly aided by systematic rubbing and movements.

We have presented this case in considerable detail, partly because it was a most interesting clinical study—being, indeed, a whole clinique in itself—and partly because the case, taking all things into view, the extent and gravity of the symptoms, the extreme impairment of nutrition, and the rapid and permanent improvement under electrization, is one of the most remarkable on record.

CENTRAL PARALYSIS.

Central paralyses are those which depend on some morbid condition of the brain, spinal cord, or sympathetic.

Hemiplegia and paraplegia, with their complications, are the more frequent and imporant manifestations of paralysis of central origin.

Hemiplegia.—Hemiplegia, which is the symptom for which electrical treatment is usually employed, may arise from :—

1st. Cerebral effusion following apoplexy.

2d. Indurations or tumors.

3d. A coagulum formed in an artery, from altered nutrition of its wall.

4th. Obstruction of a cerebral artery by fibrin detached from one of the valves of the heart.

5th. A softened condition of the brain.

6th. Sudden congestion of the brain, in which as a rule the paralysis is merely temporary; exhaustion of the brain.

7th. Lesion of the spinal cord immediately below the decussation of the pyramids.

In the vast majority of cases unilateral paralysis of the body depends upon the first of the above-mentioned causes, viz., apoplexy, and it is in this condition especially that electrization is oftentimes of very considerable value.

Although hemiplegia is the symptom of cerebral or central disease for which electrization has been chiefly recommended and employed, it by no means follows that it is necessarily more effective in this condition than in some other of the accompanying symptoms and complications. The incipient stages of disease of the brain, which are variously manifested by vertigo, cephalalgia, melancholy, insomnia, and so forth, are especially amenable to electrical treatment. It is better to prevent than to cure. *If the premonitory and incipient symptoms of cerebral disease and the attendant nervous exhaustion were always promptly and skilfully treated by galvanization of the brain and sympathetic and general electrization, the number of cases of hemiplegia would probably be much diminished.*

Affections of the Joints.—Sometimes in hemiplegia there arises inflammation of the shoulder-joint, caused by the pressure of the sunken head of the arm upon the surface of the joint.

The symptoms are: flattening of the shoulder, similar to that which appears in all paralyses of the deltoid—this may go on even to subluxation; vague pains in the arms, that are increased through movement; raising the arm in a vertical direction causes pain and loud crepitation.

The prophylaxis and treatment consist in passive movements. Some cases have been observed by Charcot and by Hitzig.*

Electro-Diagnosis.—In the electrical treatment of cerebral and *cerebellar* paralysis it is of supreme importance to make, so far as possible, a diagnosis of the precise seat of the lesion, as well as the general nature of the morbid process.

1. When the morbid process is in the large hemispheres, electric examination indicates a convulsive or exhausted condition. This condition is also associated with convulsions and contractions. By the aid of other associated symptoms we may be able to localize the disease more definitely.

2. When the morbid process is in the central ganglia, the reaction may be either normal or increased.

3. When the morbid process is in the *pons* or *medulla oblongata*, there arise *crossed reflex contractions*. If this condition is associated with facial paralysis, the lesion may be regarded as situated in the facial nerves. In crossed reflexes the lesion is in the inferior half of the *pons*.

Diminution of reaction in the healthy side of the body, in hemiplegia, indicates disease, especially tumors of the *pons* and spinal cord.

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* Virchow's Archiv, xlviii. p. 345. 1869.

Difficulties of swallowing indicate disease of the *pons* and the medulla oblongata.

In paraplegic paralysis from disease of the brain, the lesion is in the *pons* or *medulla oblongata ;* in this case the cranial nerves are also affected.*

Cerebral paralysis may result from adynamia. Electric reaction is usually diminished in such cases.

When dizziness is excited by a very mild galvanic current, there is reason to suspect some morbid process within the brain. The diagnosis of the diseases of the brain with which hemiplegia is associated is much aided by the ophthalmoscope, which frequently reveals changes in the optic disc, the retina, the choroid, and their blood-vessels. *Cerebral effusion* may be indicated by congestion or infiltration of the optic discs on the side on which the clot exists ; *tumors of the brain* by neuritis, neuro-retinitis, and ischæmia ; *softening* occasionally by neuritis or atrophy.

It should be remembered that the characteristic symptoms of the different forms of cerebral and cerebellar paralysis, especially their reaction to the electric current, do not always show themselves immediately after the attack. The characteristic reaction to the electric current may not appear for several weeks.

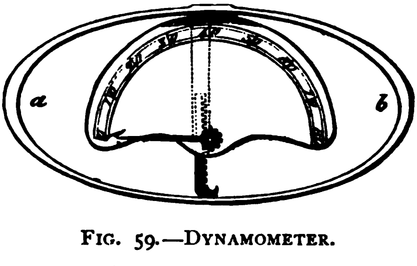

FIG. 59.—DYNAMOMETER.

The dynamometer (δυναμις, strength, and μετρον, measure) of Mathieu, of Paris, is a very useful contrivance for estimating the muscular strength of the hands in paralysis of the upper extremities in hemiplegic patients. This instrument consists of an elliptical steel spring, to which is attached a semicircle of gilt brass, upon which a scale is marked. An indicator, with a small cog-wheel at one end, may be moved freely around the arc of the circle by a steel arm, upon one side of which cogs are cut, fitting into those of the indicator. The lower end of this arm touches the elliptical spring when the indicator points to zero on the scale; a brass sheath on the under side of the scale keeps this arm in place, at the same time letting it move freely. When pressure is taken off the indicator does not return to zero, but remains at the point to which it has been carried by the muscular power of the patient.*

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* For a more extended discussion of the complicated subject of the differential diagnosis of the seat of the lesion in hemiplegia, see Benedikt's Electrotherapie, pp. 210, 211.

Prognosis.—The prognosis of hemiplegia under treatment by electrization is in general much better than has been supposed. Manifestly, everything depends on the nature and seat of the affection as well as on the age and constitution of the patient.

The prognosis is better in proportion as the symptoms are uncomplicated; better in the young and middle-aged than in the old. *Cases that are so thoroughly cured as to leave no marks behind are exceptional. The improvement, however rapidly it may progress at first, usually stops at some point short of a perfect cure.* It is furthermore always necessary to bear in mind the liability to other attacks; very many cases are improved at once and rapidly, while with others the progress is almost imperceptibly slow.

In *psychical* symptoms (melancholia, hypochondria, etc.), the prognosis is often most favorable. A persistence of these psychical complications, even when other symptoms appear to yield, we have come to regard as an unfavorable sign.

In *anæsthesia*, when uncomplicated with other symptoms, the prognosis is remarkably good, even when variously complicated with paralysis of motion, disorder of the cranial nerves, and the anæsthesia may yield, even though its associated symptoms are not affected.

In severe *disorders of speech* the prognosis is not very favorable. They are, however, susceptible of treatment.

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* Dr. Clymer in Am. edition of Aitken's Science and Practice of Medicine. Vol. 2, p. 990. See also Dr. Hammond's article in Psychological Journal. Vol. 11, p. 141, 1868.

In *impairment of nutrition*—the muscular atrophy that so frequently accompanies hemiplegia—the prognosis, especially when the cases have not been too long neglected, is oftentimes exceedingly favorable. *After the affected lower limbs have become much reduced, they may by persevering faradization and galvanization be restored to their normal size.*

In *contractions of muscles* and convulsions, the prognosis is unfavorable.

In disorders of bladder and rectum, the prognosis is not very favorable.

In *affections of the joints the prognosis is not very favorable.* (See p. 392.)

Other conditions being the same, the prognosis is much better for those cases where the arm is not affected; and when both the arm and leg are affected, the leg is susceptible of the earliest and greatest improvement. The chief difficulty in the hand is usually with the *extensors* and *inter-ossei*, which, being very long and weak muscles, and acting as they do at the worst power of the lever, are the greatest sufferers in hemiplegia, and are very slow to resume their normal functions.

It should always be borne in mind that the tendency of the disease is toward recovery up to a certain extent, and that the improvement which takes place in the early stages, sometimes very rapidly, is partly due to nature and time.

Of 28 cases of hemiplegia of various forms and degrees in which we have noted the results, 2 may be said to have recovered entirely; 4 approximately recovered; 10 were decidedly benefited; 5 were slightly benefited; 4 were not benefited; and in 3 cases the results were unknown. Just how many of the cases have been again attacked we are unable to say. We know that in two of the cases where the improvement was very decided, there have been renewed attacks.

The *Practitioner* records the following results of galvanization:—

"Dr. Emil Fliess, of Berlin, relates the results of the treatment of 85 cases of hemiplegia with the constant (galvanic) current. The patients were of all ages, and the disease was of most various origins in the different cases. Two methods were employed: 1. Galvanization of the sympathetic by placing one pole on the cervical sympathetic of each side, or else one pole on one sympathetic and the other on the spine or on the course of a cerebro-spinal nerve, or on some indifferent spot. 2. Central galvanization, a current being passed either from front to back of the brain, or along the spinal cord or 'centripetal,' two points of a nerve-trunk being included in the circuit. Of 64 cases treated by the first plan, 5 were cured and 9 were much improved; of 50 treated by the second method, 2 were cured and 7 much improved; 7 patients were also cured by the combined use of both methods. Only a slight improvement, or none at all, was noted in the rest of the cases; in one the treatment did harm."

It would appear from these statistics of Fliess that galvanization alone is far less efficacious than general electrization. General faradization, unaided by galvanization of the brain or sympathetic, rarely fails to be of essential service in hemiplegia.

Electrical treatment of hemiplegia.—Diseases of the brain of the different varieties are to be treated by both general and localized electrization, according to the indications of each case. General faradization alone is of immense service in all relievable forms of hemiplegia. In order to accomplish all possible results by this method of application, attention should be given to the head and sympathetic as well as to the periphery. It is unquestionable, however, that benefit is derived from applications to the periphery—especially to the affected side. General electrization is frequently indicated in hemiplegia as in other manifestations of disease of the brain, on account *of the general debility of the functions that accompanies and follows an attack of disease of the brain. It improves the general nutrition.*

Galvanization of the head and sympathetic with a very mild current is a method of treatment that is of great service in these conditions. (For method of galvanizing the brain and sympathetic, see pp. 174–176.) The special form and locality of the galvanization will depend on the supposed locality of the disease.

It is well to use localized galvanization of the brain and sympathetic alternately with general or localized faradization.

There is little doubt that this method of treatment, when not overdone, materially aids the process of absorption; it certainly acts beneficially on the nutrition of the brain, as of other parts of the body.

It must be confessed, however, that the exclusive use of localized galvanization through the supposed seat of the disease in cranial disorder is far from being satisfactory, and for these two reasons: *First.* With all our improved means of diagnosis it is impossible to fix with anything more than approximate certainty the seat or even the nature of the morbid process in diseases of the brain; hence, all localization of the galvanic current in this or that part of the head must at best be empirical and tentative. *Secondly.* Diseases of the brain are usually accompanied and followed by general feebleness that demands constitutional treatment.

General electrization (galvanization or faradization) thoroughly used affects all parts of the brain and the sympathetic at each application, and in addition powerfully and beneficially affects the entire periphery. The improvement which is acquired by the extremities and by all the superficial muscles, and by the viscera especially, under general electrization, we believe *reacts favorably on the brain and aids the reparative process. Our best results thus far have been obtained by the alternate use of general faradization and galvanization of the sympathetic and through the head.*

In regard to the *time* of beginning treatment after an attack of hemiplegia, each case must be studied by itself. As a rule it is better to wait two or three weeks, until the active irritation in the brain has in a measure subsided. The almost universally entertained idea, that it is better in all cases to wait three, four, or six months, until the muscles have been long atrophied and contracted, and the shoulder-joint become perhaps permanently immovable, before beginning electrical treatment, is one of the most serious errors of electro-therapeutics. *If proper caution* be used, it is never necessary to injure the patient at any stage of the disease. Cases that are taken early may be treated at first by exclusively localized faradization; and afterwards, when that has accomplished all that it can and the patient ceases to progress, it may be well to resort to general faradization and central galvanization. Passive movements of the limbs and systematic kneading of the muscles by an expert may be very advantageously used in connection with the electrical treatment. Electrization of the facial muscles on the affected side sometimes materially aids the speech, but it may cause unpleasant symptoms, and in the early stages especially should be avoided. *Mild* galvanization may sometimes be used before faradization of the muscles.

Left hemiplegia—Slow improvement of nutrition and size of limbs under general faradization and localized galvanization—Subsequent relapses.

CASE 65.—The patient was a stout, plethoric man, somewhat past the prime of life. For years it had been his custom to drink five or six times of brandy daily, although he rarely became intoxicated.

During the early part of 1868, while stepping from a Third Avenue car, he became unconscious and fell to the ground, and although he arose by his own unaided efforts and walked several blocks to his own house, he remembered nothing of the act. His reason returned several hours subsequently, when his right side was completely paralyzed. He remained perfectly helpless for several weeks, when a certain degree of strength gradually returned, so that, by the aid of a cane, he was able to walk short distances. He first observed some decrease in the size of the limb about six weeks after the attack; and when he began treatment by electrization, the thigh had decreased in circumference one inch. There was considerable diminution of electro-muscular contractility and sensibility in the affected leg, besides a marked decrease of the normal temperature. The faradic current alone was used, and in six weeks' time, after receiving twenty applications, the limb had increased in circumference half an inch, the muscular contractions were normal, and but little difference could be noticed between the temperature of the two limbs. In the treatment of this case it was not supposed that we should be able to remove the cause.

The process of absorption was apparently slow, but atrophy of the muscles was at once arrested. The normal electro-muscular contractility was restored, the temperature of the limb was increased several degrees, and its nutrition generally was so much improved that it regained its original size.

Two years subsequently the patient was again attacked, and was again treated with slight benefit.

Right hemiplegia coming on gradually, with numbness and coldness in right leg; slight anæsthesia of right hand, and considerable of right leg; some diminution of electro-muscular contractility in right leg—Gastralgia, insomnia, and great mental depression—Important improvement under general faradization and peripheral galvanization—Subsequent renewed attack.

CASE 66.—Hon. Mr. G——, aged 52, for many years U. S. senator, was referred to us Oct. 19, 1868, by Prof. Austin Flint. During the excitement of the Impeachment Trial the patient, whose constitution was always supposed to be of the strongest, observed a feeling of coldness of the right leg at night. This coldness, however, was not very marked, since his attention was first called to the condition by his wife. One day, while in Congress, and shortly after the delivery of his opinion on the Impeachment, he experienced a slight attack of hemiplegia, which he endeavored to walk off.

Before coming to New York, he had received the very pernicious advice to take vigorous and severe muscular exercise. Acting upon this unfortunate suggestion, he had seriously injured himself at the exhausting labor of chopping wood. He grew decidedly worse, and became exceedingly depressed. Under the advice and medication administered by Prof. Flint he had measurably improved, and at the time we first saw him there was a tendency toward recovery. He complained, however, of persistent insomnia, considerable gastralgia, with indigestion, pain in the lower part of the back, and very great mental depression.

Electric examination.—Slight anæsthesia of right hand; considerable of right leg; some diminution of electro-muscular contractility in the muscles above the knee on the right side; no diminution of electro-muscular sensibility; the volitional power of the muscles was intact, and the patient could walk a considerable distance.

The case demanded a general tonic as well as merely local treatment, and we accordingly used general faradization daily, or every other day, occasionally making use of galvanization. It was not long before improvement was manifest in all the leading symptoms. He soon began to sleep and to digest better, and was much relieved of the pains in the back. At the end of five weeks the patient abandoned treatment, and so far improved that in the early part of December he resumed his seat in Congress, and during the entire winter continued in the exercise of his official duties.

While under treatment by electrization, he at the same time continued the use of bromide of potassium and other internal remedies, with special reference to the affection of his stomach. Inasmuch, however, as he had been taking these remedies before, and as the improvement received important and quite rapid acceleration shortly after electrization was commenced, it seems fair to infer that this improvement was mainly due to the latter.

In the spring following the patient visited Europe, where, as we were informed, he was engaged to plead in a case at law. The excitement brought on a new attack, and that again was followed by another, which left him in a condition of despondency from which, however, he has slowly rallied.

Hemiplegia associated with decided atrophy of the leg—Rapid increase in the size of the limb following the use of the localized and general faradization and galvanization of sympathetic.

CASE 67.—Mr. Y——, aged about 60, was sent to us by Dr. De Forrest Woodruff, Sept., 1869. About six months previously the patient had suffered from a severe attack of apoplexy, resulting in paralysis of the left side of the body. In four weeks he so far recovered that he could walk to a carriage, and in three months was able to walk out at pleasure and unattended. The left leg had, however, decreased in size, measuring in circumference three-quarters of an inch less than its fellow of the opposite side.

Fifteen applications of the faradic current increased the circumference of the limb in one month half an inch.

Hemiplegia of left side in an octogenarian—Slight temporary improvement under three faradizations—No further treatment.

CASE 68.—Rev. Dr. G. S——, aged 86, was sent to us June 24, 1869, by Dr. Willard Parker, with hemiplegia of left side, the result of a slight apoplectic attack three weeks before.

The patient, though so very old, had enjoyed most excellent health until the time of the attack, and until the age of eighty had filled a responsible and laborious position as pastor of a prominent church in the city.

Electric examination showed no loss of electro-muscular contractility in the affected side; volitional power, though sensibly impaired, was sufficient to enable the patient to walk with the aid of a cane. No disorder of speech or of intellect. The hearing had been for a long time greatly impaired.

Three applications of local faradization gave some temporary relief. The patient then went into the country, since which time we have heard nothing of him.

The above case is of interest, as showing that even in the very aged electrical treatment may be used without injury.

Hemiplegia of left side, of four months' standing, complicated with affection of shoulder-joint and atrophy of muscles of fore-arm; diminution of electro-muscular contractility and sensibility—Some improvement under general faradization—Relapse possibly caused by too severe galvanization of head.

CASE 69.—Mr. D., aged 60, was referred to us Oct. 12, 1868, by Professor Isaac E. Taylor. Four months before the patient was prostrated by a stroke of apoplexy, from the effects of which he had slowly rallied. The attack had been preceded by severe anxiety, that was supposed to be the leading cause of his affliction. At the time we first saw the patient he was confined to bed, his left arm useless by his side, and only with great difficulty and pain could be forcibly extended. It was a task to raise him from his bed to the invalid's chair by its side.

Electric examination.—Great diminution of electro-muscular contractility and sensibility in the arm, with considerable anæsthesia and slight diminution of electro-muscular contractility in muscles of leg above the knee; but very little anæsthesia.

The extensors and flexors of the fore-arm were much atrophied, and the skin of the hands presented a dry, shrivelled appearance. The shoulder-joint was moved only with pain and difficulty, and presented many of the features described in the cases of Charcot and Hitzig.

Psychical symptoms were prominent, the patient being excessively nervous, somewhat irritable, timid, and so sensitive as easily to be moved to tears. The conjunctiva of both eyes considerably injected, pain through the brow and in the side and back of the head on the right side; very much constipated; fair appetite; no difficulty of speech. The prognosis for recovery was not favorable.

Under general faradization the patient was temporarily benefited, and for several weeks retained considerable improvement. He was able to step with assistance; felt more hopeful; electro-muscular contractility in left leg nearly normal. Dec. 15 we resorted to localized galvanization of the head, with at first negative and afterwards apparently unpleasant results. That the galvanic current was used too strong or too long for the condition of the patient we had some reason to suspect from a relapse that occurred Dec. 21. The symptoms almost indicated effusion. The patient lay for some hours in a semi-comatose condition, and the muscles of the affected limb relapsed into their former condition. He again somewhat improved under treatment.

While hemiplegia in the majority of instances doubtless depends on some serious anatomical lesion of the brain, it may occur without demonstrable organic change. It is doubtful whether there can be any serious disturbance of the functions of the body without corresponding structural change. Since, however, in many cases of incurable disease science utterly fails to detect anatomical lesions, we are under the necessity of clinging to the term *functional*, as descriptive of this condition. Any or all of the functions of the great nervous centre may be disturbed from what we call purely functional causes. Prolonged intellectual exertion or excessive mental depression may cause temporary and even very prolonged paresis of the intellectual, sensory, or motor functions of the brain.

Among others, the following case presented an excellent opportunity of studying an example of paralysis from the foregoing causes: —

Case 70.—Mr. H., a bank president, aged about 45, after having enjoyed excellent health previously, and having always led a correct life, was suddenly prostrated one morning while dressing, by a slight sensation of vertigo and a feeling of utter exhaustion. In the course of an hour these symptoms were followed by a partial paralysis of the right side. He was unable to walk alone, but if allowed to lean on another for support, he could slowly and with difficulty make his way from one room to another. In order that the case may be fully appreciated, it will be necessary to notice his physique and speak briefly of his past history. He was tall and *very* thin, with a tendency to anæmia rather than to plethora. He had always enjoyed a fair degree of health, and for many years there had been scarcely a perceptible variation in his weight. His present position was not at all onerous, but most of his life had been spent as head of a business firm that had taxed his energies to their utmost.

For some months previous to his illness he had suffered from excessive anxiety because of financial embarrassments, but especially because of the inefficiency and carelessness of his son, to whom he had intrusted certain details of business of much importance. His mental condition produced insomnia that finally resulted in a sudden collapse of the debilitated nerve-centre. An application of general faradization caused immediate but only temporary increase in the power of the paralyzed members, as may be so frequently noticed in cases of hemiplegia following effusion. On the succeeding day, however, very marked and permanent improvement was observable, an idea of which may be conveyed by stating that he was able to do what before was impossible, viz., put on his pants without assistance.

Treatment was given every other day, and resulted in very rapid progress toward recovery.

In the course of a month he could walk with such ease and readiness that no one would have supposed that he was in any way disabled. He could not, however, run with any ease or comfort; and although nearly two years have elapsed since treatment was discontinued, he does not feel that he is able to engage in any exercise more severe than a rapid walk.

Probable cerebellar paralysis of two months' standing; right leg and left arm most affected—Approximate recovery under general faradization.

CASE 71.—Mr. F. H. C., aged about 50, was referred to us by Drs. Purple of this city and Cooper of Brooklyn. The patient, who for many years had attended to his business affairs with remarkable diligence, and had uniformly enjoyed most excellent health, stated that during the last two years his strength had sensibly declined.

Some two months previously, while in a stooping position, he was suddenly seized with vertigo, together with an appreciable loss of power in the right leg and left arm, and marked anæsthesia in the right foot. Several recurring attacks induced his physicians to submit the patient to the influence of electrization.

Nov. 23, 1869, the patient received his first application of a mild faradic current to the head, neck, spine, and extremities. At this date he was quite weak and remarkably nervous.

No special improvement was noticed after the first and second applications, but the third resulted in a sensible decrease in the intensity of the anæsthesia.

Every succeeding application imparted strength to his limbs and improved his general condition, and in two months he had approximately recovered.

GLOSSO-LARYNGEAL PARALYSIS (GLOSSO-PHARYNGEAL PARALYSIS).

The distinctive features of this affection are paralysis of the muscles of the tongue, lips, soft palate, and also of the pharynx and larynx. There is difficulty both in speaking (especially in pronouncing certain letters) and swallowing. The saliva dribbles. Food is sometimes forced into the nostrils or larynx. In the last stage there is debility and difficulty of respiration.

These symptoms are caused by atrophy of the motor roots of the nerves, with gradual destruction of the nerve tissue.*

Prognosis.—This disease is believed to be surely fatal in a few months. Faradization of the pharynx and tongue is, however, of essential service in relieving the difficulty in deglutition, and also some of the other symptoms.

Glosso-pharyngeal paralysis of nine months' standing—Great difficulty in speaking and swallowing—Temporary and decided improvement under faradization and galvanization of the affected parts.

CASE 72.—Mr. K——, aged 43, a short, stubby, plethoric German, consulted us May 18, 1867, with marked and typical symptoms of glosso-pharyngeal paralysis. His difficulty of speech was very great, and any attempt to read was exceedingly ludicrous. His especial difficulty was in pronouncing certain vowels, as a, u. In eating, particles of food were thrown up in the upper and posterior pharyngeal space, and liquids sometimes were expelled through the nostrils.

The patient referred the beginning of his symptoms to a very severe cold.

Three localized faradizations were followed by manifest improvement in most of the symptoms, and especially in the swallowing.

May 29 galvanization was commenced, and was continued with still further improvement both in speaking and swallowing.

Of the issue of the case we have never heard.

Glosso-pharyngeal paralysis, with hemiplegia of left side of three years' standing—Chronic pharyngitis—No improvement under a short course of electrization.

CASE 73.—Capt. George H., aged 55, consulted us on Oct. 15, 1866, with symptoms of hemiplegia and glosso-labial paralysis. Certain letters, as h, p, he could not articulate, and conversation was a matter of considerable difficulty. He could walk, but needed assistance in ascending stairs or crossing streets.

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* Vide Trousseau's Lectures, Bazire's Translation, part 1, p. 130; also, Aitken's Practice, vol. 2, p. 505, for a fuller account of this disease.

The accompanying symptoms were in every way discouraging. The patient was partially insane. Naturally kind and genial, he had become excessively irritable and inconsiderate; was at times impatient and violent.

Localized and general faradization, attempted for a short time, proved of no service, and the patient was not encouraged to continue treatment. We afterwards learned that his symptoms gradually became worse, in spite of various hydropathic, equalizing, and other methods of cure that he attempted, and in three years he died.

SPINAL PARALYSIS—PARAPLEGIA.

Paralysis of the lower limbs (paraplegia), or general paralysis, may result from a variety of morbid conditions of the cord. The exact differential diagnosis of the various morbid conditions of the spine is usually a matter of considerable difficulty, and for these three reasons:—

1. All known morbid conditions of the cord have more or less symptoms in common. Thus, for example, paralysis of the lower limbs with anæsthesia and diminution of electric irritability, feeling of constriction around the body, tenderness of the spine, pain, heaviness, and burning in the back, with affections of the bladder, rectum, and sexual organs, may result from a number of species of organic diseases of the cord. In order that any of them may be of special diagnostic value, it is necessary that they should be taken in connection with other symptoms.

2. Many of the morbid conditions of the cord overlap, run into, or are complicated with each other, and the symptoms must be correspondingly complex. Thus, meningitis may exist with myelitis, and the term myelitis itself is a genus of which there are several species. It is difficult to draw the line where irritation ends and congestion begins, and equally difficult to determine at what stage a condition of hyperæmia or congestion becomes a condition of inflammation. The pathological condition that gives rise to the symptoms of locomotor ataxy, degeneration of the posterior column, disintegration of the posterior cornua, may pass into and become complicated with disease of the anterior cornua, with the symptoms of muscular atrophy.

3. Many of the symptoms associated with paraplegia or general paralysis are common not only to the different species of

myelitis, spinal hyperæmia, and spinal paresis, but also to locomotor ataxy and spinal irritation (diseases in which true paralysis does not exist), and to hysteria in certain lesions of the brain. The difficulty is rendered greater by the fact that disease of the brain and spine may co-exist.

By the combined study of the special symptoms, the history of the case, and the results of treatment, it is possible, however, to make a tolerably accurate differential diagnosis in nearly all cases of disease of the spinal cord.

Of the various symptoms of disease of the cord, those which point to some variety or stage of *myelitis* are anæsthesia and paraplegic paralysis; a feeling of a cord around the body; a loss of control over the bladder and rectum; feeling of burning when a piece of ice or sponge filled with warm water is applied near the seat of the disease; atrophy of muscles of lower limbs; bed-sores, no necessary pain in the back or tenderness of the vertebræ on pressure. Those which point to *spinal congestion* are incomplete paraplegic paralysis; tingling in the extremities; twitching of the muscles; heaviness and dull pain in the spine, increased by a recumbent position or by exercise; no disposition to bed-sores; no want of control over bladder or rectum; absence of anæsthesia.

The symptoms which point to *chronic meningitis* are pain on motion of the spine or lower limbs; twitchings of the muscles; incomplete paralysis; difficulty of breathing. In all these three conditions, myelitis, meningitis, and congestion, spinal tenderness may or may not exist, according to the stage and degree of the disease. It is more likely to occur in the earlier than in the later stages; difficulty of walking comes on gradually. In all these conditions there may also be the shooting pains in the lower limbs, and either coldness or heat of the extremities—usually the former.

In all these conditions, also, reflex action may be diminished, increased, or destroyed.

Those symptoms which point to simple *spinal exhaustion* are the hysterical tendency, absence of the usual symptoms of organic disease, and rapidity of recovery.

The presence of a *tumor* may be suspected when the reflex movements are exceedingly violent, when the lower limbs are drawn up and spasmodically flexed.

The one symptom that induces a suspicion of *hemorrhage*, or serous effusion in the cord is paraplegia with suddenness of the attack.

Softening may be suspected by the observance of cramps, pain in spine, and other symptoms of active inflammation or congestion.

Spinal Sclerosic Paralysis is indicated by the formative stage of weakness in lower limbs, tremor following weakness and excited by movement, and later by rigidity of limbs and spasms.*

Comparing these symptoms with those of the first stages of locomotor ataxy and spinal irritation, it will be seen that some are common to all these conditions, and that the differential diagnosis can only be made out by the subsequent history of the case.

Ophthalmoscopic Examination of Retina.—Bouchut, who has pecially studied cerebroscopy, thus epitomizes his conclusions concerning the relation of diseases of the spine to retinal appearances:—

"The diseases of the spinal cord, such as acute myelitis, spinal sclerosis, locomotor ataxy, &c., produce usually a congestive lesion, and subsequently atrophy of the optic papilla."

"The lesions of the optic nerve producing spinal disease are the result of a reflex ascending congestive action, and they take place by the intercommunication of the great sympathetic."

"The presence of a hyperæmia of the optic nerve, of a vascular diffusion over the papilla, and of a partial or total atrophy of this part coinciding with feebleness or numbness of the legs, indicates the existence of acute or chronic disease of the spinal cord."

Electric Examination.—In the early stages of spinal paraplegia the galvanic and faradic reaction may be normal, but in the course of a few weeks or months becomes diminished. In most of the cases that consult the physician there is diminished or destroyed electro-muscular contractility. This feature helps to make the differential diagnosis between spinal paraplegia and locomotor ataxy.

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* On the differential diagnosis of disease of the spinal cord, see Dr. Radcliffe's paper in Reynold's System of Medicine, vol. ii., pp. 580, *et seq.* It is hardly necessary to say we entirely disagree with his statement that tenderness on pressure of the vertebræ is conclusive evidence of the non-existence of organic disease.

Electro-muscular sensibility is usually more or less diminished. Electro-muscular contractility is usually much more diminished in the severe forms of paraplegia than in hemiplegia.

Treatment.—Spinal paraplegia should be treated by galvanization of the spine, general faradization, and peripheral faradization or galvanization ; to depend on one method solely is unnecessary. Whether general faradization is to be employed, will depend on the general condition of the patient. In the early or subacute stage the séances should be short ; in the chronic stages the séances may sometimes be very protracted. In many cases the general tónic effects of general faradization alone are of very great service.

Prognosis.—Nearly all cases of spinal paraplegia can be benefited by electrical treatment, but very few can be entirely or permanently cured. We may look for perfect recovery in some cases that are taken early, and in cases that depend on hysteria or exhaustion. Cases of myelitis, meningitis, congestion, and non-inflammatory softening, may improve quite rapidly under electrical treatment up to a certain point. The patient hopes for and expects permanent cure ; he is usually disappointed in this expectation, for the improvement usually stops short at a definite limit. In our hands general faradization alone has been exceedingly efficacious in a number of instances, and mainly *from its general toning effect.*

Usually, however, we alternate general faradization with galvanization of spine or of the periphery, especially in cases in which the electro-muscular contractility is much diminished.

Of 11 cases of organic paraplegia of various kinds that we have treated, 1 was approximately cured, 1 decidedly benefited, 4 slightly benefited, 4 not benefited, and 1 case of myelitis died.

(Cases of reflex paraplegia will be treated of under reflex paralysis.)

Spinal congestion—Tenderness and pain of the lumbar and other vertebræ ; weakness and partial paralysis of the lower limbs ; hysterical symptoms—Improvement under galvanization of the spine, after failure of general faradization.

CASE 74.—As an illustration of a very considerable loss of power in the lower limbs from well-marked spinal congestion, we refer to the case of a married lady aged 35, who was placed under our care by Dr. J. O. Farrington. Some four years previously she first began to notice certain symptoms for which she could not account, but which evidently indicated some disturbance of the circulation, and possibly some slight spinal irritation.

She was then regarded as hysterical, and was really tormented with many of those vague and various symptoms which accompany this condition. Associated with her general nervous distress at that time, however, were a number of special symptoms, which she readily called to mind on being closely questioned. The most prominent of these was a sensation of tenderness when by any accident or design pressure was made over the lower part of the spinal cord. She recollected also that this sensation of tenderness was accompanied by pain in the lower part of the bowels and in the extremities, and frequently a disposition to nausea.

These symptoms became neither much aggravated nor decidedly improved, but continued to annoy her until about five months before she came under our observation, when a great change for the worse manifested itself.

Quite suddenly she found that the power of locomotion was considerably impaired. Slight exercise fatigued her more and more, until finally she was unable to walk more than a few hundred feet without becoming excessively fatigued. There was a sense of heaviness in the knees and feet, and frequently it required all her efforts to overcome this feeling of helplessness and move around. There was no anæsthesia; but she complained of a constant tingling in the fingers and toes.

Pressure, when made over any portion of the spine, caused no feeling of tenderness; but at night the warmth of the bed frequently produced a dull aching of the cord, which effectually prevented sleep.* Both night and day she was annoyed at intervals with paroxysms of shortness of breath.

Hoping to equalize the circulation, and thus help to relieve the congestion which was supposed to exist, we made use of the faradic current. We could accomplish nothing with it, and resorted to the galvanic current, placing the negative electrode at the coccyx and passing the positive up and down the spine—spinal-cord current. The application was administered every other day, and was followed by good results. The sensation of tingling of which she complained was entirely dissipated.

The annoying shortness of breath was so much relieved that it was only occasionally and at night that she was troubled by it. Her feet became permanently warmer, and she was able to increase somewhat her amount of exercise without suffering fatigue. These results were accomplished in two months, during which time thirty applications of the galvanic current were made.

The prominent symptom which pointed to spinal irritation as the original difficulty in the case of this patient was the sensitiveness of the spine to pressure, and the accompanying nausea and pains.

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* Increase of pain in the back, when in a recumbent position, indicates congestion.

The symptoms which indicated the later stages of congestion were:—

First—Incomplete paralysis in a paraplegic form.

Second—A constant tingling in the toes and fingers.

Third—A dull aching along the spine, caused by warmth.

Fourth—Shortness of breath.

These symptoms, together with the absence of some of the prominent indications of myelitis, viz., anæsthesia, paralysis of the bladder and sphincter ani, impairment of electro-contractility and electro-sensibility, and also of tenderness on pressure along the spine, which does not accompany the graver diseases of the cord when not associated with spinal irritation—all these fully confirmed the diagnosis of congestion of the cord.

In its early stages the above case might have been classed as spinal irritation. (See p. 351.)

Paraplegia resulting from myelitis, with debility, insomnia, anæmia, dysphagia—Improvement of all the symptoms under general faradization and localized galvanization—Relapse.

CASE 75.—Mrs. D., aged 51, married, was referred to us by Prof. John T. Metcalfe, on Oct. 12, 1868. For two years she had been afflicted with paraplegia, which was preceded by loss of control over the rectum, and which was brought on by exhaustion incident on loss of sleep and over-exertion in attendance in the sick-room.

She could walk a short distance, but ascending stairs was very difficult. Among the accompanying symptoms were unpleasant dysphagia, insomnia, very feeble appetite and digestion, and poor circulation—in short, general functional debility. The patient could not walk at all in the dark. There was no pain in the back, but a constant feeling of weakness. No feeling of constriction.

Electric examination showed a considerable loss of electro-muscular contractility and sensibility in the affected limbs, but no anæsthesia.

Before consulting us she had received positive benefit from general faradization. We employed for three months general faradization and galvanization of the spine, and at first with benefit. The patient hoped for a complete and permanent cure. In this respect she was disappointed. Although her *sleep improved immediately* after the employment of general faradization, and although her strength much increased, yet the power of walking was increased only to a certain degree, which under further treatment it seemed unable to pass.

The patient retained her improvement for several months; but in the following autumn was again somewhat prostrated, and again received the same treatment, together with galvanization of the sympathetic, and with substantially the same result.

In the above case there were three points of interest.

1. General faradization was more beneficial than galvanization of the spine and of the sympathetic, although the spine was unquestionably the seat of the disease.

2. The patient seemed in a measure dependent on the tonic influence of electrization, since it operated more rapidly and more powerfully up to a certain point than any internal medication which she had faithfully tried.

3. The case illustrates the limitation of even the most successful electrical treatment in many cases of organic paralysis.

Paralysis resulting from myelitis, with severe constipation—Very great dyspepsia and debility—Susceptibility to electrization—Slight improvement at first under electrization.

CASE 76.—Mrs. B., a married lady of middle life, had for several years been afflicted with paralysis of left leg. The patient was of a nervous constitution, and she attributed her condition to over-work and anxiety attendant upon keeping house and entertaining company. At the time we saw her, February 14, 1868, she was able to walk only with difficulty, and her vitality was feeble. The affected limb was very cold, and was three-fourths of an inch smaller than the other above the knee.

Electric examination showed loss of electro-muscular contractility in the affected limb. *A strong faradic current localized in the spine caused pain and uneasiness in the knees, which lasted for several days.*

This phenomenon we have observed to so marked a degree in no other case.

The patient was exceedingly constipated, and was obliged to depend on alvine injections. At various times there had been a feeling of a cord around the waist. At the time we saw her there was no spinal tenderness. The patient was at all times dyspeptic and feeble.

Treatment by general electrization previously administered had relieved her dyspepsia and improved her general condition.

On account of the peculiar susceptibility of the patient, we abandoned treatment after a few trials.

Paraplegia dependent on meningitis and myelitis—Traumatic origin—Loss of control over bladder—Bed-sores.

CASE 77.—Mr. C., aged 28, was sent to us March 11, 1868, by Dr. W. C. Wey, of Elmira. The history of the patient was that in February, 1863, while an officer in the army, when in the act of swinging an axe, he felt a slight *twitch in the back.* Shortly after came a diarrhœa, with pain in the calves of the legs, cold feet, then a desire to urinate with inability, then pain and stiffness in the back. He grew weaker and weaker, and for two years was confined to his bed. There remained large scars of former bed-sores.

Electric examination.—Great anæsthesia of the bladder, slight diminution of electro-muscular contractility, and considerable anæsthesia in the lower limbs. The urine was continually dribbling, so that the patient was obliged to wear sponges and disks.

The patient could walk only with the aid of crutches. He was treated by general faradization and localized galvanization. After seven sittings he returned very slightly improved.

There was no improvement in the condition of the bladder.

Spinal hemorrhage, resulting in paraplegia, with profound anæsthesia of the legs and absence of electro-muscular contractility below the knees.

CASE 78.—L. F., a gentleman aged about 60, was seen by invitation of Dr. S. T. Hubbard. The patient was suddenly prostrated while in his office by an attack of spinal apoplexy, and during the several weeks that had elapsed before he fell under our observation, the muscles of the thighs and legs had become decidedly atrophied and flabby.

Control was partially lost both of the bladder and rectum. The legs were profoundly anæsthetic, and below the knees there was an entire absence of electro-muscular contractility.

The use of both the galvanic and faradic currents for several weeks appreciably relieved the anæsthesia, and approximately restored the electro-muscular contractility. The electricity was discontinued, but the patient improved in strength, probably as the spinal effusion absorbed, and in a number of months was able to walk by the aid of a cane.

Myelitis finally involving the whole cord and resulting in death—Electro-contractility and sensibility completely impaired, but no atrophy of or decrease of temperature in the legs.

CASE 79.—Mrs. W., aged about 30, experienced some loss of power and certain pains of a neuralgic character in the lower extremities a few hours subsequent to a bath in the surf. These symptoms rapidly increased in severity, and within a week the lower limbs, together with the bladder and sphincter ani, were complely paralyzed. By the advice of Drs. Flint and Buck, we saw the patient six weeks after the attack, and found that while both electro-contractility and sensibility were entirely abolished, the circulation was so little impaired that the limbs retained their usual size and temperature.

The spine was not at all sensitive to pressure, but tenderness was manifest on the application of the faradic current over the lumbar portion of the cord.

All efforts to arrest the disease proved unavailing.

The inflammation gradually extended upward, and finally the upper dorsal and lower cervical portion became involved, interfering with the heart's action, and causing death.

PARALYSIS OF THE SYMPATHETIC.

Under this head Meyer*, Driessen†, and Althaus‡ record a few cases of paralysis of the upper and lower limbs, or of both, sometimes associated with general nervous symptoms that yielded to galvanization of the cervical sympathetic, and are therefore supposed to be cases of paralysis of that part of the nervous system. The diagnosis is made partly by exclusion, partly by the symptoms, and partly by the results of treatment.

That paralysis of the sympathetic may be the pathological condition in certain disturbances in nutrition, motion, and sensibility, is rendered highly probable by these considerations:—

1. It has been shown by Bernard and Schiff (quoted by Meyer) that the fibres of the sympathetic take origin in the anterior roots of the spinal cord. It would therefore be reasonable to suppose that disease of the sympathetic would be associated with disease of the cord; and that disorders of nutrition are frequently associated with paralysis resulting from spinal disease is fully sustained by clinical observation.
2. It has been shown by Bernard, Schiff, Budge, and Ludwig, that the vaso-motor nerves are of central origin and proceed from the terminal ganglia of the sympathetic.
3. It has been shown clinically that certain conditions that appear to be associated with disease of the sympathetic, are positively benefited by galvanization of its cervical ganglia.

Remak was of the opinion that *diphtheritic paralyses* were connected with the sympathetic. This opinion was based on the fact that they sometimes followed very mild cases when the neck was affected, and attacked places far distant from the seat of the disease.

According to Meyer§ the electro-muscular contractility is normal in diphtheritic paralysis, and this disease is greatly benefited by electrization of the affected part and of the phrenic nerve.

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* Op. cit., p. 242 et seq.

† Althaus, op. cit., p. 469.

‡ Op. cit., p. 471.

§ Op. cit., p. 249.

Paralyses that occur in chlorosis and hysteria may not unlikely be connected in some way with the sympathetic.

In rheumatic gout and in progressive muscular atrophy the sympathetic is believed to play an important part.

Chronic meningitis and probable affection of the sympathetic, resulting from an attack of cerebro-spinal meningitis—Mydriasis of the left pupil—Anomalous sensations in the head—Unpleasant results from galvanization and faradization.

CASE 80.—Mr. J., aged 29, was referred to us April 4, 1870, by Prof. St. John Roosa. His history was as follows:—Up to 1858 he had been perfectly well. At that time he lost his voice—was unable to sing as usual, and even reading seemed to tire the vocal apparatus. He found it difficult to pronounce certain words, and was compelled to find substitutes. For two years he was troubled with night-sweats, and in summer especially found himself very weak in the morning.

In 1865 he was *attacked with cerebro-spinal meningitis,* which left him with chronically congested condition of the spinal *cord, and probably some affection of the sympathetic.* When we first saw him he was considerably debilitated, with great weakness in the back, and sense of vacancy in the eyes and brows. Examination revealed a tenderness of the lower cervical and the dorsal vertebræ. His symptoms were peculiar and changeable. Every hour or half hour his morbid sensations would assume a different phase and attack a different locality. A sensation which he frequently experienced in his head he could only compare, he said, "to eternity." Sometimes he felt as though he were standing on a precipice, and was being carried far away into space. His appetite was fair, his sleep very good, and his muscular strength very considerable. The pupil of his left eye was always dilated. He had been obliged to leave the confining occupation in which he had been engaged, and take a position as conductor on a horse car. One day while standing on the platform of the car, he suddenly lost his power; the stamps fell from his hand, but in a minute he recovered himself. Electrical treatment, in the form of faradization and galvanization of the spine, was faithfully tried, but without good results. The day following the application he complained of pains in his limbs and in his body generally, which led him at first to believe *that he had taken cold.* These symptoms were unquestionably due to the irritation of the spinal cord.

These disagreeable reactive effects of the electrical treatment were not followed by any demonstrable permanent effects, and for that reason *ice and blisters to the spine,* with the internal administration of *acid phosphate,* were prescribed. Under this treatment the patient gave evidences of improvement.

Chronic congestion or inflammation of the membranes of the cord in the above case was rendered probable by the history and by the symptoms. Moreover, there were no positive evidences of any organic disease of the cord itself. That the sympathetic also was in a morbid condition might be suspected from the persistent mydriasis,* from the tendency to perspiration, and from the anomalous attacks to which he was subject.

Probable attacks of temporary paralysis of the sympathetic, with great nervous prostration—Attacks of dizziness and falling—Great accumulations of gas in the bowels.

CASE 81.—Rev. Mr. B, a clergyman, 34 years of age, began to be taken, in the spring of 1870, with attacks of dizziness while in the act of prayer in his pulpit. When he was on a level with the audience, the attacks were less frequent and less severe. On one occasion he had been prostrated after overworking in his garden. During the summer, which was exceedingly warm, he was unusually sensitive to the solar rays. One evening, while in the act of retiring, he was prostrated for a minute with a sensation as though he had been severely struck on the top of the head. During his attacks in the pulpit, it was necessary for him to hold on firmly to keep from falling. One Sabbath he was so distressed that he was obliged to cut short the exercises. His congregation observed that he turned pale. His speech was uncertain, and he made slips of the tongue.

These attacks were followed, on his return to his house, by the expulsion of large quantities of gas from his bowels. These accumulations were frequently enormous. Relief was obtained when free perspiration appeared.

In the intervals the patient suffered from general nervous prostration and sensations of pain and uneasiness at the top of the head and down the spine. His muscular strength was but little impaired; he was capable both of walking and of working.

The patient inherited a highly nervous and impressible organization, which had been considerably increased by his manner of life. He had suffered from attacks nearly similar several years before.

In this case there was, in addition to the nervous exhaustion, strong reason to suspect a morbid condition of the sympathetic. It is probable that the heat of the sun was one of the last exciting causes. The patient was advised to take a vacation for two months, to use ice to the spine, to take acid phosphate internally, to try mild wines to which he had been unaccustomed, and to avail himself of treatment by galvanization of the sympathetic and general faradization. Shortly after adopting the medical and hygienic part of the treatment he began to improve.

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* On the relation of the sympathetic to contraction and dilatation of the pupil, see the very able essay of Dr. Robert Edes—Prize of the New York Academy of Medicine.

That, in the above case, the dizziness appeared while he was in the act of prayer and not while preaching, is to be explained by the fact that during extemporaneous prayer the *eyes are closed.* Difficulty of standing with closed eyes is a symptom that is experienced in a large number of cases of irritable and organically diseased conditions of the spinal cord. It is observed in hysteria, in myelitis, in spinal irritation, or in congestion, as well as in locomotor ataxy.

It is, therefore, not necessarily a very bad symptom. A clergyman informed us that three times in his life he had suffered in this way, and with improvement in his general condition had entirely recovered.

INFANTILE PARALYSIS.

Paralysis in infants, though often of a reflex character, is so frequently dependent on some morbid condition of the spine, that it is properly included under *spinal paralysis.* The frequency with which paralysis occurs in infancy, its persistence, and the life-long misery and helplessness which frequently attend it, render the subject one of vast importance.

This form of paralysis has been treated of by Rilliet and Barthez,* under the title of "*Paralysie Essentielle de l'Enfance,*" and by Duchenne,† who gives it the name "*Paralysie Atrophique Graisseuse de l'Enfance.*"

Cases of infantile paralysis, as described by Hanfield Jones,‡ were of a temporary character, that recovered under the influence of tonics. Such cases may disappear in a very short time. In absence of positive knowledge, we may perhaps assume that such cases are analogous to the so-called hysterical or functional paralysis of adults, which is not supposed to be dependent on any spinal lesion, at least of an inflammatory character.

The opportunities for post-mortem examination in cases of infantile paralysis have not been sufficiently numerous to enable us to state with positiveness what the predominant morbid lesion is that gives rise to this disease. Prof. Hammond* found in one case of paralysis of the left lower extremity, of four years' standing, a cicatrix containing a very small clot in the anterior column of the lower dorsal region.

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* Maladies de l'Enfance, 1853.

† Op. cit., p. 275.

‡ Functional Nervous Disorders, Am. ed., p. 92.

It is probable that the disease may and does arise from the same variety of morbid conditions that cause spinal paralysis in adults—exhaustion, congestion, meningitis, myelitis, apoplexy, and so forth. Neither on theoretical or clinical grounds is it necessary to assume the existence of any morbid process in the spine giving rise to paralysis that is peculiar to infants.

The symptoms of the disease are ***paralysis with loss of electro-muscular contractility, some anæsthesia, great diminution of temperature, and muscular atrophy.***

The disease often comes on suddenly. Premonitory symptoms of distress in the back and febrile disturbance sometimes occur. In some cases the muscular atrophy is accompanied by fatty degeneration.

Duchenne, with the aid of the microscope, has investigated the condition of the muscles in muscular atrophy.† For this purpose a trocar is necessary. Duchenne's trocar, Fig. 60, is introduced into the muscle open. When *in situ*, a piece of sharp steel is pushed, by means of a button, against the barb of the trocar. A piece of muscle is thus caught, which, on the withdrawal of the trocar, can be examined.

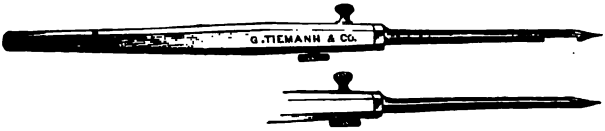

FIG. 60.—Duchenne's Trocar.

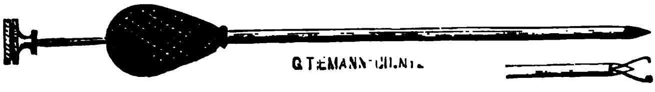

FIG. 61.—Noeggerath's Trocar.

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* Note to Meyer, p. 233.

† Op. cit., pp. 510 et seq.

Noeggerath's instrument, Fig. 61, is introduced as a simple trocar, and when *in situ*, the wire contained in it, being pushed forward, causes the prongs or clasps on its extremity to emerge a little separated. When the wire is pulled out the prongs come together, bringing with them a piece of the flesh.

We present the cuts of Duchenne, with condensed explanations.

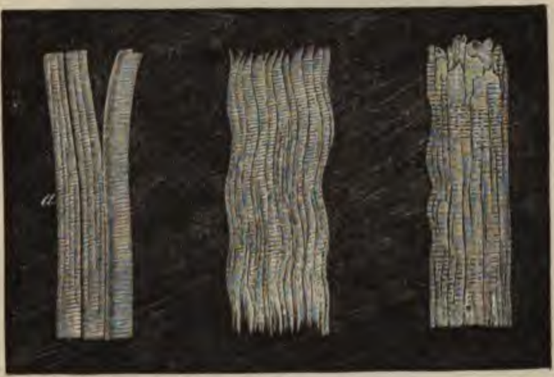
Normal fibre. ——First degree.——

FIG. 62. FIG. 63. FIG. 64.

Fig. 62 "represents the normal fibres, with the transverse striæ."

Figs. 63, 64.—"The transverse striæ are less distinct; they are frequently broken; the longitudinal fibres are more and more marked."

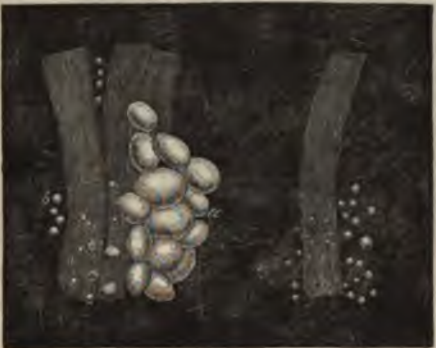
Second degree.

FIG. 65. FIG. 66.

Fig. 65.—"The muscular fascia is composed entirely of longitudinal fibres, the transverse striæ having completely disappeared."

"By the side of the muscular fibre adipose tissue is observed, composed of cells that are either (*a*) round or longitudinal; there are little drops (*b*) of fat deposited in the muscular fibre."

Fig. 66.—"The muscular fibres have still preserved their contractility, and are undulating."

Third degree.

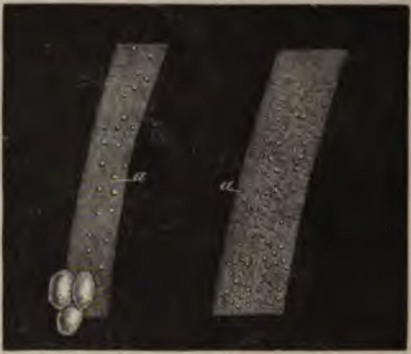

Fig. 67. Fig. 68.

Figs. 67, 68.—"The longitudinal fibres have become less distinct. The molecules of fat are more and more abundant—again cover the figure almost entirely." (See Fig. 93.)

Fourth degree.

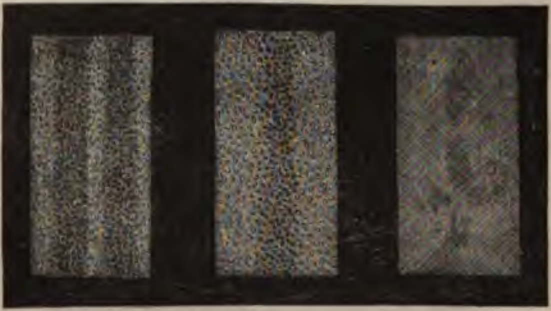

Fig. 69. Fig. 70. Fig. 71.

Fig. 69—"The longitudinal fibres have disappeared. We see only fatty molecules very close together and little distinct, especially towards the axis of the fascia."

FIG. 70.—"The fat becomes more abundant and diffluent; the muscular fascia is more transparent."

FIG. 71.—"Distinct molecules of fat are no longer perceptible; the fascia is composed of a shapeless mass.

"Each degree of fatty transformation corresponds to a degree of decoloration of the muscular fibre."

This process of shrinkage may go on long after the original morbid condition of the spinal cord has disappeared.

Prof. Hammond,* who has investigated infantile paralysis by the method of Duchenne, has found that even in some long-standing cases there were no evidences of fatty degeneration. It may be regarded as a frequent but not uniform accompaniment of infantile paralysis.

Early Symptoms.—The onset of an attack in the child is not always marked by any outward sign of disturbance (such as convulsions, drowsiness, etc.) of the central nervous system. The child may go to bed perfectly well to all appearances, but in the morning the parents find an arm or a leg powerless. In other cases the disease advances slowly, until the loss of power in certain parts is complete. If in any case the tendency of the disease is towards recovery, a few weeks will frequently suffice for the paralyzed member to regain its usual strength; but if in the course of that time no improvement is manifest, it is reasonably certain that Nature alone will never accomplish more than a partial cure. In the latter case the affected limb soon commences to decrease in size, the muscles become soft and flabby, the circulation weak, and the surface cold. At the same time the child usually remains healthy both in mind and body. In many cases the disease is evidently reflex in character, and is excited by irritation of some portion of the mucous surfaces, by the sudden or continued influence of cold, or more frequently, perhaps, by the irritation of teething.

Electro-diagnosis.—In infantile paralysis there is diminution or utter loss of electro-muscular contractility. In patients so young the condition of electro-muscular sensibility cannot o course be ascertained. The tactile sensibility is in some cases much diminished; in other cases it does not appear to be enlarged.

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* Loc. cit., p. 237.

A slight degree of anæsthesia cannot be ascertained in very young patients. An important feature of infantile paralysis is that the muscles exhibit contractility under galvanization when they are not at all affected by faradization. In this disease especially both currents are necessary in the diagnosis as well as in the treatment.

In making an examination of the condition of the muscles of infants it should be remembered that, on account of their flabby character and the relatively large proportion of adipose tissue by which they are surrounded, they do not respond as readily nor as perceptibly to electrization as the muscles of adults.

The differential symptoms of cerebral and spinal paralysis in children, according to Heine, are as follows: In cerebral paralysis there is an appearance of mental deficiency or weakness, or some disturbances of sight or vision, cephalalgia, and stiffness and immobility of the muscles. In spinal paralysis there are no cerebral symptoms, and there is a relaxed condition of the muscles, and besides more atrophy and a greater loss of temperature than in paralysis of a central origin.

Treatment.—Galvanization of the affected limbs is the method ing, frictions, and the application of dry heat and hot water to the affected limbs.

It has happened that several of our most satisfactory results have been obtained under general faradization.

Prognosis.—The prognosis must depend on the cause, the probable nature of the lesion, the length of time that the disease has existed, and the condition of the muscles, especially as ascertained by electric and microscopic examination. If fatty degeneration is much advanced the prognosis is less favorable than when no degeneration exists.

Cases of a reflex or functional character may recover speedily without special treatment. Cases of organic character, which constitute the majority, and which have gone on to atrophy, recover only slowly and under faithful, persistent treatment. It is rarely indeed that parents or guardians have the patience or the means to persevere and obtain the full benefit of which electrization is capable.

Frequently the improvement rapidly advances to a certain grade and then halts, or advances so imperceptibly as to discourage the parent. Electrical treatment in these cases is very greatly aided by energetic frictions, systematic kneading of the muscles with both hands, and by bathing the limbs in hot salt water.

We have records of 9 cases of infantile paralysis that we have treated. Of these, 4 recovered, 1 approximately recovered, 2 were decidedly benefited, and 2 were not benefited.

Paralysis of left arm; atrophy of deltoid—No response at first to faradization—Improvement, but not recovery, under galvanization.

CASE 82.—In the first instance the little patient, a boy aged 14 months, was suddenly taken with complete paralysis of the left arm after exposure to cold. He came under our observation about a week after the seizure. We found it impossible to produce the slightest contractions of the muscles with the faradic current. After two applications we resorted to the galvanic current.

Immediate contraction of all the paralyzed muscles followed its use, and the natural power was restored somewhat, so that the child was enabled to slowly close and open the hand. After another similar application, the faradic current was as efficacious in producing marked contractions as the galvanic.

When treatment had been continued about a month the child could use the hand and fore-arm perfectly well. The upper arm was considerably improved, so far as power of movement was concerned ; but the deltoid muscle had atrophied, and no subsequent treatment sufficed to greatly improve its condition.

Paralysis of left arm, with atrophy of deltoid, caused by exposure to cold—No response at first to faradization—Improvement under galvanization.

CASE 83.—A short time before we saw the child he had been exposed (with bare arms and shoulders), while riding in the horse-cars, to cold draughts of wind. A few hours subsequently the mother first noticed that the child used the right arm altogether, and upon further examination she discovered that the left arm was perfectly powerless. Previous to the attack the little patient had been suffering considerably from the irritative process of teething, which had somewhat reduced him in health and flesh. The deltoid was atrophied. No intensity of the faradic current which we felt justified in applying to the affected arm produced the slightest effect ; but when a galvanic current of moderate power was made use of, the muscles of the paralyzed limb responded almost as readily as those of the healthy side. The improvement under the use of the galvanic current was for a time quite marked. He very soon regained full power over the hand and fore-arm, but was unable for a long while to move the upper arm, and when treatment was discontinued after some twenty applications had been given, it was impossible for him to raise the arm readily from the side. Notwithstanding the approximation to a perfect cure, the faradic current would produce only feeble contractions, while under the influence of the galvanic current the electro-muscular contractility was vigorous.

Paralysis of right leg following diarrhœa—Rapid recovery under general

For about a week the paralysis was complete, but as the fever abated he seemed to regain some power over the affected limb, and when convalescent he was able to move it quite freely. After some weeks, when he had gained a good degree of strength, the little patient found it possible to move slowly about by the aid of a crutch.

His limb ceased to progress now that he had entirely recovered from sickness, and when his parents applied to us, a year subsequently, the boy still continued unable to move about without artificial support.

He was unable to flex the right foot or raise the limb from the floor without flexing the leg.

The muscles of the thigh and leg had atrophied to a considerable extent. By measurement the calf of the paralyzed limb was found to have decreased in size one inch.

The parts were cold and flaccid, and it was almost impossible to distinguish the pulsations of the posterior tibial artery, which in the healthy limb were full and strong.

As the general health was good, we made the application of the faradic current to the paralyzed muscles only. Their electro-muscular contractility was very much impaired, and the current was much less acutely felt than on the corresponding portion of the sound limb. Applications were administered twice a week for one month, resulting in a complete restoration of the electro-muscular contractility, and a very decided increase in his sensitiveness to tactile impressions and in the warmth of his limb.

At the end of another month of treatment the leg had increased in circumference one-half an inch, and the patient was able to walk with comparative ease without the aid of any artificial support.

Infantile hemiplegia of the right side in a child of two years—Not treated.

CASE 86.—A child of two years was brought to us October 23, 1868, by our friend Dr. Cowdry, with hemiplegia of right side, that had come on three weeks before with an attack of screaming. The general condition and nutrition of the child had been good.

Electric examination.—Slight diminution of electro-muscular contractility in the affected side, yet the response to the faradic current was sufficient for all the practical purposes of electro-therapeutics.

The patient had been treated by Dr. C. by faradization, with some improvement. Of the results we have not been informed.

PERIPHERAL PARALYSIS.

A true peripheral paralysis manifestly excludes all lesions or influences of a central origin.

The cause must be sought for in some portion of the nerve-tract after it has emerged from the bones that enclose the nervous centres.

It was formerly quite common to ascribe all paralyses to a central origin. Recently, however, physiological investigation and a more careful study of pathology show that the majority of cases of local paralysis depend upon peripheral causes. Of these causes we have :—

1. *The action of cold on the superficial distribution of nerves as one of the most frequent.*
2. *External injuries.*
3. *Pressure on a nerve from morbid growths, etc.*
4. *Destruction of a nerve by carious bone, etc.*
5. *Arrest of the arterial or venous circulation.*
6. *The determination of some poisonous influence generated without or within the system to a certain nerve.*

FACIAL PARALYSIS.

Palsy of the seventh pair of cranial nerves is one of the most common and distressing of local paralyses, and it may follow any one of the above causes, with the exception of the fifth. Depending on the first and last causes, it is very generally curable, while if it results from the third or fourth the prognosis is, as a rule, unfavorable, and even death may occur from meningeal inflammation or cerebral abscess. The symptoms of facial paralysis vary not only as its cause is central or peripheral, but also according to the portion of the nerve affected. Paralysis of the seventh pair without coincident paralysis of an arm or leg seldom results from cerebral hemorrhage. It may occur, however, but it may be readily distinguished from the peripheral form of the affection. *In complete facial paralysis of peripheral origin the orbicularis palpebrarum muscle is paralyzed, and the eye cannot be entirely closed; while if the cause is central this muscle is, as a rule, unaffected, and the eyelids can be brought together.* In some exceptional cases a certain lesion may paralyze the orbicularis muscle, while occasionally, in peripheral facial paralysis, the nerves that supply the muscles of the eye may escape, thus leaving it free to close. The fact that in facial paralysis of central origin the electro-muscular contractility is unimpaired, while if the nerve itself is the seat of the injury the muscles refuse to respond to either current, materially aids us in diagnosis.

Electro-diagnosis.—In facial paralysis of a peripheral origin, the *farado-muscular* contractility is usually diminished or lost; *galvano-muscular* contractility may be *increased* or normal; though in some cases it may be diminished, it is rarely lost. Facial paralysis is one of the conditions in which the difference between the two currents, in their power of producing contractions of muscles, is typically shown. The galvano-muscular contractility sometimes becomes so much increased that when the farado-muscular contractility is entirely abolished, the diseased muscles respond to a much feebler galvanic current than is necessary to produce contractions on the healthy side. As the muscles resume their normal condition under treatment, the galvano-muscular contractility diminishes.

Treatment.—Facial paralysis should be treated by peripheral faradization and galvanization. In cases that are supposed to depend on central disease, mild galvanization of the brain and sympathetic are indicated and faradization of the affected muscles should be used with great caution.

Prognosis.—This depends so much on the special pathology that it is hard to lay down any general rule. In uncomplicated cases it is usually favorable. We have treated 8 cases. Of these 5 recovered, 1 was decidedly benefited, 2 were not benefited.

Facial paralysis from exposure to cold—Loss of contractility to faradic current —Improvement under the galvanic current.

CASE 87.— Miss P., a stout, vigorous young lady of fifteen, was sent to us by Dr. F. Elliott, to be treated for paralysis of the seventh pair, on the left side, caused by exposure to a draught of air two months previous. The paralytic symptoms came on suddenly and in full force immediately after the exposure, and at first she experienced considerable difficulty in speaking.

She gradually became so accustomed to the abnormal condition of her lips and face that she was able to converse almost as clearly as before; but the improvement in the condition of the paralyzed muscles was very slow, and at the time she came to us the affection appeared to be almost stationary. At the time she received the first application at our hands (Aug. 1, 1862), she presented most of the usual symptoms of paralysis of the seventh pair.

Her mouth was drawn over towards the healthy side so violently as to produce considerable deformity when she laughed or conversed, and even when she smiled. When she attempted to frown, the left brow remained as smooth as that of a child.

Her left eye rolled up, and when she attempted to close it, the lids would not approach nearer than one-quarter of an inch to each other. A powerful faradic current, localized in the affected muscles, produced very feeble or imperfect contractions; while on the sound side a very mild current, applied with the hand, produced active contractions of all the principal muscles. The patient was so well in all other respects, that we decided to use only partial or localized electrization over all the muscles on the left side of the face. Two vigorous applications made in this way, one electrode being placed firmly in front of the ear, and the other passed over the ramifications of the seventh pair as well as over the individual muscles (Fig. 42, p. 179), did not seem to increase to any appreciable extent the electro-muscular contractility, and accordingly we resolved to adopt an entirely different method of warfare.

The next time we localized the galvanic current through the left side of the face, and with the best results. Contractions of the paralyzed muscles were at once produced that were as vigorous and as natural as those caused by the faradic current on the healthy side, and by a current that had no effect on the healthy side.

The patient began at once to improve, and after ten visits, distributed over a period of six weeks, she was dismissed as approximately cured. There still remained some deficiency of action of the muscles concerned in frowning and in winking, but the expression of her face, both in repose and in conversation, was normal.

The interesting points in this case are these :—

First.—The galvanic current produced contractions and wrought a cure when the induced or faradic utterly failed.

Second.—The paralyzed muscles were at first brought to contraction by a galvanic current *that had no effect whatever on the muscles of the healthy side.* As the patient improved, however, it became necessary to use a stronger galvanic current in order to produce the contractions. Towards the close of the treatment, the muscles of the paralyzed side began to respond to the faradic current. These apparent inconsistencies had also been previously observed by a number of the German electro-therapeutists, and also by Legros and Onimus. The late P. Victor Bazire* has recorded an experience almost precisely similar.

Partial paralysis of the right side of the face, with contraction of muscles following neuralgia—Approximate recovery under localized faradization.

CASE 88.—Miss J., aged forty, came to us in the early part of September, 1868, to be treated for a facial paralysis of a peculiar character. Her face was drawn to the right side, so that her features were very much distorted. We at first supposed, and very naturally, that the case was one of paralysis of the seventh pair of the *left* side, but a more careful examination led us to modify our diagnosis.

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* Notes to Translation of Trousseau's Lectures on Clinical Medicine, Part II., p. 331.

Her history was as follows:—Several years before, while occupied in a day and night attendance at the bedside of a sick friend, she was suddenly attacked with severe facial neuralgia of the *right* side, that continued to annoy her for two months. The disease then abated, but since that time she had been frequently harassed by persistent numbness in the right arm and hand.

On localizing a strong faradic current through the muscles of the *left* side of the face, powerful contractions were excited. On the *right* side no such effect could be produced.

Furthermore her right eye was nearly closed, owing to a partial ptosis, and while she could easily frown and corrugate the left brow, the right was entirely smooth and expressionless. It was very evident, both from the history of the case and from symptoms at the time, that the *right* side was paralyzed, and not the left, as at first appeared, and that the face was drawn towards the right by the contractions of the *muscles following the paralysis.*

Trousseau has described this condition so accurately that we quote his own language as it appears in the translation of Bazaire.*

After relating the symptoms of a patient suffering from paralysis, he says:—"If left facial paralysis was thought of at first sight, the depression of the lower lid, and the less marked expansion of the nostril on the right side, were already sufficient to cause a modification of the diagnosis. But when the patient attempted to move that side of her face there could no longer be any hesitation, and it became manifest that it was the right side which was affected. When she spoke, and still more when she laughed, her face was pulled with force to the left, the upper lip and the ala nasi on that side going obliquely upwards, and the labial commissure being drawn with considerable energy upwards and outwards. When she attempted to blow, her left cheek swelled and her mouth remained closed on that side, whilst her right cheek was flaccid and her mouth opened out a little on that side. Besides, she could not shut her right eye, however much she tried."

In this case we used only the faradic current, localizing the electricity as nearly as possible along the course of the portio dura and its ramifications. To accomplish this the small positive electrode was pressed firmly on the point where the nerve emerges from the temporal bone, while the negative was moved along its various terminal branches (Fig. 42, p. 179).

No particular results were obtained from the first application, but during the second visit slight contractions were produced on the right side, and it was then noticed that the eyelid did not fall so low as before.

In the course of a few days the patient again visited us, when the improvement was quite marked. There was considerable relaxation of the contracted muscles, and the electro-muscular contractility was readily demonstrated. At the fourth visit, which occurred about two weeks from the commencement of treatment, the ptosis was hardly noticeable, and the power of corrugating the occipito-frontalis on the right side was perfect. There still remained, however, some distortion of the features, owing to the obstinate nature of the muscular contractions, and, although she subsequently received quite a number of applications, the contraction was not so entirely dissipated as were all the other symptoms. But the amelioration was so complete that the distortion was little noticed, and ceased to give her any considerable annoyance.

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* Lectures on Clinical Medicine, Part II., p. 322.

Double facial paralysis—Probably resulting from lesion in the course of the nerves—No improvement under localized faradization.

Case 89.—Mr. M. was referred to us by Prof. A. Clark, to be treated for paralysis of both sides of face. In the month of March, 1862, during the retreat of the Confederate army from Kentucky, this gentleman, after prolonged exposure to cold and wet, was attacked with facial neuralgia Previously he had been so unfortunate as to contract syphilis, which had passed into the secondary stage; but for several years he had been, to all appearances, entirely free from the disease. This attack of neuralgia was followed by partial paralysis of the right side of the face. The neuralgia persisted until July, but the paralysis has continued constant until the present time. In January, 1866, he had a renewal of the neuralgia, which this time attacked the left side of the face. It was of an intermittent type, and on the 25th of March, without a premonitory symptom, and when he was entirely free from pain, the left side of the face became completely paralyzed. He gradually lost the sense of hearing, and in two weeks was absolutely deaf. When brought to us for treatment he was suffering from paralysis of the whole face.

He was unable to close either eyelid, could neither elevate the eyebrows nor frown. He had but little control over the mouth, and as a consequence his speech was very imperfect. "The motionless face assumed a peculiar aspect, and looked like a lifeless mask, on which the impressions of the soul were no longer expressed but by changes of color." We had but little hope of benefiting him, nor were we disappointed; for after a month of faithful and hopeful perseverance on the part of the patient, not the slightest improvement was observed. For a little time after an application he seemed to possess more control over the muscles of the eye and mouth, and his articulation was evidently more distinct. The galvanic current was not used.

By far the most important treatise ever offered on the subject of traumatic paralysis, and one of the most readable of recent contributions to the department of nervous diseases, is the little monograph of Drs. Mitchell, Morehouse, and Keen. As this work, valuable as it is, is in the hands of comparatively few physicians, we thought it best to condense very briefly some of their leading observations and conclusions. For details we refer to the work itself.*

These observers were enabled to study and record 120 cases of injury to nerves, which are treated of under the following heads :—

Primary effects of wounds and other injuries of nerves.—These are shock (which is treated of under reflex paralysis), paralysis of motion and sensation, the former being unaccountably more frequent than the latter, and pain elsewhere than in the wound.

Injury of nerve-centres.—A ball passing over the spine posteriorly may cause paralysis of motion and sensation.

Injury of sympathetic.—In one case, the passage of a ball behind the ramus of the jaw on the right side, by the anterior border of the sterno-cleido-mastoid muscle, and emerging in front of the jaw on the left side, caused headache, contracted pupil, ptosis, congestion of conjunctiva, unilateral flush on exertion, and appearance of altered size of eye-ball.

Injury to nerves.—Wounds of nerves sometimes affected other branches of the plexus. This effect may be attributed either to reflex action or to extension of inflammation. A prominent effect of injury to a nerve is impairment of nutrition, and of the muscles supplied by that nerve. This waste is accompanied by enfeeblement of the pulse, that may be either slow or rapid. It may attack one muscle or several muscles. Atrophy begins with flabbiness, and may result in contraction caused by shortening of opposing muscles, or by spasms. Atrophy from pure cerebral palsy rarely if ever exists. The three results of injury to a nerve—paralysis of motion, of sensation, and atrophy—do not necessarily go together; they occur in the same case in different degrees.

Glossy or shining skin, resembling cicatrices of wounds, was observed. The part loses its wrinkles and its hair.

Eczematous eruptions were often observed. Sometimes they came and went, being absent for several weeks. A very interesting fact (and one often observed in other conditions) was that the recurrence of the eruption relieved certain painful symptoms; when the eczema came back the pain declined.

The nails and hair.—The hair disappeared from the affected fingers; the nails became deformed, and even more markedly than in tuberculosis. This deformity consisted in "a curve in its long axis, an extreme lateral arching, and sometimes a thickening of the cutis beneath its extremity." In other cases "the skin at that end of the nail next to the third finger-joint becomes retracted, leaving the sensitive matrix partly exposed. At the same time, the upper line of union of skin and nail retreats into or under the latter part, and in those of a smooth edge is seen through the nail as a ragged and notched border."

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* Gunshot Wounds and other Injuries of Nerves. By S. Weir Mitchell, M. D., George R. Morehouse, M.D., and William W. Keen, M.D., Acting Assistant Surgeons in charge of U. S. A. Wards for Diseases of the Nervous System, Turner's Lane Hospital. Philadelphia: J. B. Lippincott & Co. 1864.

Pain of a burning character accompanied the glossy skin.

Inflammation of the joints resembling rheumatism, and resulting in partial anchylosis.*

The secretions of the wounded limbs were either excessive, or the reverse; sometimes the perspiration was altered, became acid like vinegar, or in some way disagreeable.

Lesion of sensation.—Rarely there was either cutaneous or muscular hyperæsthesia. Anæsthesia is not a constant symptom, even where electro-muscular contractility was entirely lost.

The electric brush is the final test of paralysis of sensation; it may reveal sensation when other tests fail.

Pain following injuries to nerves may be of a dull, darting, or *burning* character. *Burning* neuralgic pain is a most distressing symptom that may long remain after the healing of the wound, and it is usually, though not always, associated with the glossy skin. The temperature of the burning part was raised.

Numbness, with many other abnormities of feeling, was observed from slight injury to a nerve. It sometimes existed in parts where no loss of sensibility could be detected by the æsthesiometer.† Deficiency in the power of localizing sensation was noticed in traumatic as in spinal paralysis.

Influence of wounds upon muscular movement.—Nerve lesions cause muscular paralysis, contractions, or alterations in the joints.

Spasms or tremors may occur.—In spasmodic shortening of the muscles, the electro-muscular contractility is normal or increased.

Diagnosis, prognosis, and treatment by electrization.—The remarks of the authors on this subject nearly agree with what has already been stated in previous chapters. The points of special interest which they mention are that electro-sensibility may be greatly heightened through hyperæsthesia of the muscles, so that the current will not be borne; that a diseased muscle may respond to the will and not to the electric current (as pointed out by Duchenne); that faradization should be discontinued when pain appears, although the appearance of pain is a good symptom; that spasmodic contractions of long muscles would not yield to electrization of the opponent muscles; and that in nearly all cases the faradization must be used with great perseverance.

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* We have observed the same in a case of hemiplegia. *Vide* Remarks on Affections of Joints in Hemiplegia.

† We have observed the same phenomena in paralysis from cerebral and other causes. *Vide* chapter on Anæsthesia.

Pathology of Injured Nerves.—According to Erb, definite and important changes take place in the nerve after it has been injured. At first there is congestion of the marrow, which becomes divided into cylinders; these cylinders merge into oil globules, surrounded with granules of fat, and the fibres increase in diameter. In the third week the fat and marrow diminish, and nuclei appear. The fibre becomes reduced to a small band composed of healthy fibre and axis cylinder. New marrow is now deposited around the axis cylinder of the marrow that has remained uninjured. When these have attained their full development, the nerve resumes its electro-conductibility. Regeneration, like degeneration of a nerve, takes place from the seat of injury towards the periphery.

Inflammation of the neurilemma takes place at the seat of injury, with proliferation of cells and shrinking of the connective tissue. This process appears in the neurilemma of the entire peripheral portion of the nerve. Granular spindle-shaped cells appear in the neurilemma. The neurilemma becomes thickened, and the connective tissue harder and tougher. Fibres take the place of the cells. Regeneration, though at first impeded by the hardness of the sheath that encloses the nerve-fibre, yet in time becomes complete.

MUSCULAR PARALYSIS.

Under peripheral paralysis may properly be included cases of muscular paralysis described in the "Pathologie und Therapie der Muskellähmungen," by Dr. H. Friedberg, inasmuch as this condition is very frequently of peripheral origin.

This condition consists in a disorder of the assimilative process of the muscles, and is termed myopathic paralysis, in contradistinction to neuropathic paralysis resulting from injury to the brain, spinal cord, or peripheric nerves.

In paralysis resulting from injury to a nerve the assimilative action of the muscular tissue is ultimately disturbed. This disturbance is necessarily only a secondary cause of whatever paralysis may exist.

In the so-called myopathic paralysis, however, the disturbance in the nutrition of the muscle is the ***primary*** cause not only of the loss of power, but also of the ***partial*** or ***entire*** absence of the electro-muscular contractility. The prognosis in any given case depends in a great measure upon the degree of depression in the electro-muscular contractility and sensibility in the affected part. According to the above-mentioned author, as quoted by Meyer, muscular paralysis may be induced by the following causes :—

1st. A similar disturbance in adjacent organs, communicating itself to the muscles, as paralysis of the deltoid muscle, in consequence of inflammation of the shoulder-joint, etc.

2d. The effect of external force, as wounds, excessive straining.

3d. A sudden change of temperature.

4th. Various diseases of the blood.*

5th. Deficient supply of blood, or repressed muscular movements.

6th. Unknown causes, numerous cases of progressive muscular atrophy, etc.

The following case, directed to us by Dr. J. O. Farrington, of this city, will illustrate the variety of peripheral paralysis under consideration :—

Muscular paralysis of right thigh : apparently produced by exposure to cold—Anæsthesia—Improvement under galvanization—Increase in size of limb.

CASE 90.—Miss F., aged about 20, first observed a slight pain and soreness in the muscles of the right thigh, that readily yielded to a few applications of the faradic current. Five months subsequently, after several hours' exposure to cold and wet, she experienced considerable pain in the right limb, and also a marked degree of stiffness, that disappeared temporarily after walking a few times around the room.

In a few days the pain extended to the hip and involved the whole limb, which soon became completely paralyzed, and for two weeks she suffered excessive pain both day and night. Three months later, when it was decided that the patient should be treated by electricity, she was able to move about the house with the aid of crutches, although the limb remained almost perfectly powerless.

The anæsthesia over the quadriceps muscle was very decided, the æsthesiometer producing two impressions only when its points were separated four inches, and the electro-muscular contractility was entirely absent in all the external or surface muscles of the thigh and in a portion of the leg. The thigh had atrophied to the extent of an inch and one-half.

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* Muscular paralyses from these causes, according to our classification, are to be regarded as constitutional.

Ten applications of the faradic current entirely dissipated the anæsthesia, so that it was necessary to separate the æsthesiometer but three-quarters of an inch, in order that two impressions might be received.

The same current partially restored also the electric contractility of the diseased muscles; but it was not until a *galvanic current* of considerable intensity was employed a number of times, that they responded healthfully to its influence.

The faradic current was again resorted to and persistently used for several months.

The limb gradually increased in strength, so that she was able to walk readily with the aid of a cane. It increased also in size, so that around the thigh it measured but one-quarter of an inch less than the sound limb. Time alone can tell whether she will ultimately regain complete control over the diseased member.

Paralysis from pressure.—Paralysis sometimes occurs from pressure on the nerves of the arm during sleep. It occurs most frequently in persons who are intoxicated. Such cases taken in time usually yield to electrization, but they are more obstinate than would be supposed from their causation.

Two cases of this form of paralysis have fallen under our observation.

Calorific paralysis.—Under this head Benedikt records a case of paralysis caused by the contact of glowing hot iron with the skin, at a point near the radial nerve. The nerve was not directly injured, but paralysis with anæsthesia ensued. The patient recovered after a number of sittings. Both galvanic and faradic currents were employed.*

REFLEX PARALYSES.

Under this head are included those peripheral paralyses which arise by reflex action through the central nervous system, from some remote part of the body.

The views of Brown-Séquard in regard to the pathology of reflex paralyses are so well known that it is unnecessary to more than refer to them.

Paralysis that arises by reflex action may remain long after the

* Op. cit., p. 480.

morbid condition that caused it has entirely disappeared. Many cases of paraplegia and infantile paralysis are of a reflex character. The former is most likely to be reflected from the urinary and genital organs, and the latter from the irritation of teething and diseases of the bowels.

Treatment.—Local faradization or galvanization is required in this form of paralysis. This treatment should be directed not only to the paralyzed muscles, but also in some cases to the diseased part from which the paralysis is reflected.

Prognosis.—This is much more favorable than in paralysis that directly proceeds from organic disease. Everything depends on the nature and locality of the irritation. Of our cases of paralysis 19 are registered as peripheral, of which a small proportion were regarded as reflex. Of these 6 recovered, 4 approximately recovered, 6 were decidedly benefited, 2 were not benefited, and in 1 case the result was unknown.

Typical case of complete reflex paralysis of the seventh pair on the right side of the face, following severe neuralgia of the fifth pair on the same side.

CASE 91.—The patient, a lady aged 30, had suffered severely at intervals; but some weeks previously an attack of sharp shooting pains, of far more than ordinary severity, was followed in the course of twelve hours by symptoms of facial paralysis, which gradually increased until the loss of power was almost complete.

The muscles responded to the influence of faradization, but there was a manifest decrease of the electro-muscular contractility. Three applications of the faradic current to the affected side completely restored the contractile power of the muscles, and three similar applications removed the paralysis.

Reflex paralysis of the left arm, apparently from neuralgia of short duration—Recovery under faradization.

CASE 92.—Mrs. W., aged 31, consulted us February 1, 1867. She was suffering from general neuralgia, which was especially localized in the left arm. Appetite, digestion, and sleep were all poor.

There was paralysis nearly complete of the left arm. We began treatment by general and localized faradization. In one week, after three sittings, the paralysis disappeared. Treatment by general faradization was subsequently continued, for the purpose of raising the tone of the system.

The query arose whether in the above case the paralysis was due to hysteria or the reflex action from neuralgia.*

Vide Brown-Séquard's Lectures on Paralysis of the Lower Extremities, p. 9.

We here desire to call attention to a more infrequent form of reflex paralysis, the peculiar features of which have been ably set forth in a circular issued from the Surgeon-General's office.*

In this circular the authors detail seven cases of paralysis of a remote part or parts, produced "by a gunshot wound of some prominent nerve, or of some part of the body which is richly supplied with nerve-branches of secondary size and importance."

The relation of the seat of the wound to the part or parts paralyzed was as follows:—

"2D CASE.—Fragment of shell; wound of muscle over and external to the right femoral artery. The injury may have caused concussion of the crural nerve. *Result.*—Reflected paralysis of the right arm and leg, and of the left leg.

"3D CASE.—Probable injury of the sciatic nerve (commotion). *Result.*—Reflex paralysis of the right arm.

"4TH CASE.—Ball wound of right testicle; paralysis of right anterior tibial muscle and peroneus longus.

"5TH CASE.—Wound by fragment of shell in external side of left thigh; paralysis of tact on a corresponding part of right thigh.

"6TH CASE.—Ball wound, probably involving the crural nerve. *Result.*—Paralysis of right arm.

"7TH CASE.—Ball wound of deltoid muscle; sensory and slight motor paralysis of same arm.

"In one case the left arm recovered without treatment in four weeks, leaving only a slight loss of touch in the terminal distribution of the ulnar nerve. The right arm, which we also regarded as reflectively paralyzed, recovered sensation early, but was useless as to motion until it was treated and cured by faradization, 18 months after it was first injured. Case 2 came under our care seven months after he was wounded; as to his previous treatment we know nothing. In our hands strychnia not only failed to aid him, but did harm. He was rapidly relieved by faradization, active and passive movement, and the douche, with iron, quinine, and liberal diet."

"Case 3 used a liniment on the paralyzed arm, with some improvement. Faradization has restored it completely.

"Case 4 relieved by faradization.

"Case 5, no treatment; lesion of sensation only.

"Case 6, a stimulating liniment applied upon the arm seems to have been of use. As in case 3, the employment of crutches caused a relapse."

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* Circular No. 6. Reflex Paralysis. Founded chiefly on cases observed in U. S. General Hospitals, by S. Weir Mitchell, M. D., Geo. R. Morehouse, M.D., and Wm. W. Keen, Jr., M.D. March 10, 1864.

"Case 7 seems to have been accidentally benefited through the blistering to which the arm was subjected after exposure to the sun—a useful hint in like cases. No other treatment was employed.

"In only one of the foregoing cases was there any manifest decrease in the electro-muscular contractility of the paralyzed limb."

Brown-Séquard regards the ultimate cause of reflex paralysis to be a contraction of the capillary blood-vessels of the central nervous system.

While acknowledging this explanation to be both plausible and ingenious, the authors above quoted propose another theory. They do not think it probable that contraction of the capillary blood-vessels can continue for a long time, and consequently to their minds it seems more plausible to ascribe reflected paralysis to an exhausted irritability of the nerve-centres, or else to previous paralysis of its vaso-motor nerves.

CHAPTER XXV.

LOCOMOTOR ATAXY (*TABES DORSALIS*).

THE importance of locomotor ataxy is heightened from the fact that it passes by the cradle, and leaves the aged and infirm unscathed, that it may render helpless and finally destroy those in the vigor of early and mature manhood.

When the disease is fully developed, the want of power to co-ordinate the movements of the lower limbs is so marked and characteristic, that the disorder is no more liable to be mistaken than are the symptoms which indicate chorea. Trousseau, whose descriptions are always so beautiful and life-like, thus portrays the gait of an ataxic patient: "When children walk along a narrow plank, or the edge of a boat, you must have noticed the peculiarity of their gait. In order to maintain their equilibrium, they take one step forward, stop, sometimes go backward again, and incline their body to one side or the other, instinctively putting their arms out like a sort of balancing-pole. In fact, their movements resemble those of an *unskilled rope-dancer.*"[*]

In a more advanced stage of the disease, the patient, when attempting to walk, throws his limbs about in greater disorder. His heels come to the ground heavily at every step, and unless he has a cane with which to support himself, he sways from side to side, and involuntarily extends his arms to prevent himself from falling. When walking he is inclined to keep his eyes fixed upon his feet, watching every step, for it is a peculiar feature of the disease that the sight is necessary for the preservation of the equilibrium. Let him place his feet firmly together and close his eyes, and he will immediately oscillate,[†] and will soon fall if not caught.

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[*] Trousseau's Lectures on Clinical Medicine. Part I., p. 151.

[†] The importance of this symptom—inability to stand firmly with closed eyes—has been overrated in locomotor ataxy, since it is common to very many morbid conditions of the central nervous system.

The anæsthesia, which is a premonitory symptom, and in the first stages was slight, is now more marked and general, and serves very decidedly to aggravate the inco-ordination of movement. The fingers frequently become so anæsthetic that their delicate sense of touch is lost, and their dexterity of manipulation impaired. This is owing mainly to paralysis of the *ulnar nerve*, which is a frequent premonitory symptom in this affection.

Through all this the patient may retain a good degree of strength, and will walk as far and as long on level ground as ever without fatigue.

In going up or down stairs, however, he experiences difficulty, and especially in the descent; his efforts are slow and laborious.

Further on, there comes a time when his steps are so irregular and his movements so violent, that a short walk completely exhausts him, and soon he is utterly unable to progress unless he is supported firmly on either side. Finally, he takes to his bed, never more to leave it until inevitable death, perhaps through some other disease, supervenes.

The leading and most recent ideas concerning locomotor ataxy may be thus briefly summed up:—

Symptoms.—The symptoms may be divided into *four* stages. The symptoms of the premonitory stage are various and not well defined. They are twitchings of the muscles; localized pain, or sensation of cold or numbness, of stinging, tingling, or crawling in different parts of the face; unusual disposition to fall asleep of the sciatic or ulnar nerves, on slight pressure; slight involuntary movements of the eye lids, cheeks, or lips; sudden jerkings and startings in sleep; spasms or spasmodic jerkings, referable to the stomach and head, occurring mostly at night; difficulty in grasping or handling small objects, in buttoning one's clothes, writing, or picking up a pin; specks before the eyes; pain in the back; sense of weakness in the upper or lower limbs, especially after exertion; diminution or abnormal excitation of sexual power; cottony or cushion-like feeling of the soles of the feet. These symptoms are not diagnostic; they may all occur in conditions that never go on to locomotor ataxy. They may occur in spinal irritation or spinal congestion, and may be premonitory of myelitis as well as of locomotor ataxy. They do, however, occur in cases that eventuate in locomotor ataxy as well as in other lesions of the cord, and when they occur they may give rise to the suspicion that unless remedied they will lead to locomotor ataxy, for ataxic patients experience these symptoms, and accordingly they deserve consideration.

There is little doubt that many, perhaps the majority of cases who exhibit these symptoms go no further; and there is every probability that if all cases could be treated during this stage, locomotor ataxy would cease to be regarded as incurable or even the most intractable of diseases. Unfortunately, these premonitory symptoms are not uniform, and when they do occur are so light as not to attract attention.*

Second stage.—Fugitive, wandering neuralgic pains of a stabbing, lancinating, boring, gnawing character in all parts of the body, but especially in the lower limbs, coming on at intervals; feeling of constriction in different parts of the lower limbs amaurosis, strabismus, or ptosis, diplopia, or some disorder of vision, with unequal pupils; impairment of sexual power, injection of conjunctiva. None of these symptoms are uniform, not even the neuralgic; locomotor ataxy may arise without any of these. On the other hand, myelitis is sometimes preceded for a long time by neuralgic pains in the lower limbs.

In the *third* stage is the characteristic unsteady, irregular, hitching, staggering, tottering gait; tottering when the eyes are closed and feet are close together; difficulty of going up-stairs and in turning round rapidly; sometimes difficulty of locomotion, first felt in the night time; anæsthesia and numbness in the feet and legs.

In the *fourth* stage there is aggravation of the symptoms of the third stage, sometimes accompanied with impairment of nutrition.

These different stages may be separated by intervals of several weeks, months, and even years, and the duration of the disease ranges between a few months and thirty years. As these stages also are but rarely defined in any individual case, they run into each other and form one history. The diagnosis of locomotor ataxy is not usually made until the third stage. The characteristic symptoms by which the disease is usually suspected and determined are inability to co-ordinate movements; in walking the hitching, jerking gait; difficulty of grasping and holding objects; unsteadiness when standing with the feet together and the eyes closed. These symptoms, when accompanied by a history of disturbances of vision, boring, stabbing, lancinating pains in the lower limbs, make out the diagnosis.

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* For interesting remarks on the formation stage of locomotor ataxy, see Dr. Clymer's paper in Medical Record, Feb. 1, 1870, p. 522.

It will be observed that some of the symptoms—as unsteadiness when standing with closed eyes, neuralgic pains in the limbs—are not peculiar to locomotor ataxy, but are observed also in other diseases of the spinal cord (see p. 415). The diagnosis is only made out by taking all these symptoms together.

Other symptoms that occur in locomotor ataxy are acceleration of the pulse, without increase of temperature of the body, from 90 to 124; palpitation of the heart; gastric disturbances; pain in epigastrium, with vomiting; nervous or spasmodic cough, deafness, and tinnitus aurium; paralysis of the cranial nerves; feeling of constriction about the waist; loss of control over the rectum; tenderness of some of the vertebræ; cramp of the muscles, and affections of the joints resembling rheumatism.*

The disease is sometimes complicated with muscular atrophy, ordinary myelitis, and progressive paralysis of the cranial nerves.

An interesting point in the history of locomotor ataxy is the abnormally slow rate at which the nervous force travels, and the long time that elapses before a peripheral impression is perceived by the patient.

In a case of advanced locomotor ataxy which we saw in the Charity Hospital, in Berlin, there was an interval of twelve seconds before the deep prick of a needle was felt by the patient. In one of Dr. Lockhart Clark's cases three or four, and in another *twenty* minutes elapsed before the patient felt the pain from the prick of a needle. The electric current is sometimes not felt for several seconds. Ataxic patients who cannot at once pick up a small object, may be able to do so after they have allowed their fingers to rest on the object until the impression has been transmitted to the nerve-centre.

Causation.—A prominent cause of locomotor ataxy as of progressive muscular atrophy, is *taking cold after severe exertion.* The common causation of the two diseases and their occasional complication tends to confirm the belief that the latter is also a disease of the spinal cord.

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* Die Gelenkaffectionen in Verlaufe der Tabes Dorsalis (locomotor ataxy), von Dr. Benj. Ball, Schmidt Jahrbücher. Band 146, No. 5, 1870.

It is probable, also, that locomotor ataxy may be caused by sexual excesses; certain it is that when the disease is present it is much aggravated by excitation of the sexual organs. The fact that locomotor ataxy, like spinal irritation, is usually a disease of maturity, rarely occurring before puberty or in very old age after the decay of the sexual passion, gives support to the theory that it may be brought on by sexual excitement.

The range of capacity for sexual excitation in different temperaments is so wide that it has been found practically impossible to fix any mathematical average that will apply to any considerable number of the human family. When we consider the monstrous abuses to which the genital organs are with apparent impunity subjected; that the wild excesses of fast young men are only exceptionally followed by disease of the nervous system; that the immoderation of newly-married men but rarely leads to any more than temporary disturbance; that the armies of prostitutes, whose days and nights are devoted to sexual indulgence (though not always *con amore*), are not, as has been supposed, doomed to early destruction; but, as the recent investigations of Du Chatelet and Acton have abundantly shown, attain frequently a great age, and usually a good average longevity that is often very active and useful, and sometimes even respected and happy; when we consider, furthermore, that these excesses are committed not in the full maturity of strength, but in the formative, developing, even tender period of life, we can but be impressed with the great difficulty in assigning any definite arithmetical limit for the indulgence of the sexual appetite. The truth probably is that the genital, like the digestive organs, can bear and were designed to bear a great deal of abuse, provided the system be in a normal condition and the manner of life in other respects healthy; but when the system has become exhausted by severe and protracted mental and physical strain, or impoverished by lack of nourishment, it is seriously injured by sexual indulgence, which would otherwise be harmless or beneficial. These remarks will apply to the unnatural as well as to the natural excitation of the genital organs. For some even moderate self-abuse is immediately harmful; for others it works no perceptible or directly traceable injury when indulged in for years. This general rule will hold good, that sexual indulgence or self-abuse, indulged in very early in life, at the dawning of puberty, is more likely to work harm than the same habits formed in later years.

Electro-diagnosis.—The electro-muscular contractility, or at least *irritability*, may be normal or *increased*. ***This fact distinguishes locomotor ataxy from ordinary paraplegia***, when the electro-muscular contractility is usually diminished. It may, however, be diminished in certain forms and stages. According to Benedikt,* the reaction to the *spinal cord-nerve current* is sometimes increased, with opening contractions in recent cases; in cases where the motor disturbance is prominent, the reaction may be normal or diminished. Another important peculiarity is that the descending current produces contractions more readily than the ascending. This peculiarity is usually associated with increased but sometimes with diminished reaction.

Treatment.—The electrical treatment of locomotor ataxy must be adapted to the condition and peculiarities of each. Galvanization of the spinal cord and of the sympathetic, when employed in season, has accomplished very decided results. In some cases the improvement after this method of treatment has been immediate and has rapidly progressed. Both the ascending and descending currents are used with a current of moderate strength for three, four, or five minutes. In our hands, general galvanization and faradization have been quite efficacious in improving the general condition, relieving the pains, and aiding the co-ordinating power in the incurable stages of the disease. We have not yet had opportunity to treat a case in the early stages by this method.

Galvanization and faradization of the affected limbs is also of unquestionable service, though too much dependence should not be placed on this merely peripheral treatment.

The special disorders of the eye, the ear, or of the genital organs, will need special treatment.

Prognosis.—The prognosis of this affection, when taken early and properly treated, although not brilliant, is by no means entirely unfavorable. Not only improvement but cures have been reported by Benedikt, Meyer, Frommhold, Cyon, Onimus, and others. If cases were taken in their premonitory stages, there is little doubt that very many, perhaps the majority, might permanently recover. Even in the last stages much can be done to relieve and strengthen.

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* Op. cit., p. 338.

Electrical treatment may be materially aided by the use of phosphorus.

There is little doubt that some of the cases of locomotor ataxy reported as cured by galvanization were really not cases of locomotor ataxy, but of some other disease. Thus Meyer* reports the following as a cure of locomotor ataxy:—

A gentleman "suffered for several years from frequent pollutions and nightly erections, a slight fatigue while walking, and a feeling of tension in the inner surface of the thighs, in addition to which, latterly, a feeling of being bruised between the shoulder-blades, pressure upon the chest, and lancinating pains in the lower extremities supervened." The fifth vertebra was tender on pressure. Six weeks' treatment (twelve applications) by galvanization, the positive pole being placed on the tender vertebra and the other on the hip-joint, resulted in entire removal of the symptoms. The patient subsequently relapsed after sexual excitation, and again used galvanization.

This case was a typical illustration of spinal irritation, as shown by its characteristic symptoms. Aside from the pains in the lower extremities, which very frequently occur in spinal irritation and congestion, there was no evidence whatever of even the early stages of locomotor ataxy, although it is entirely possible that the condition here described may run into either myelitis or locomotor ataxy (see p. 439). We have cured a number of cases more or less similar. (See Spinal Irritation.)

Of 8 cases of locomotor ataxy of which we have records, 2 approximately recovered, 3 were decidedly benefited, 2 were slightly benefited, and 1 was not benefited.

Locomotor ataxy—Marked characteristics of gait—Difficulty of turning around—Tinnitus aurium—Neuralgia—Diminution of electro-muscular contractility—Decided improvement under general faradization.

CASE 93.—G. M., aged 49, came under our care in September, 1868. He stated that his lower limbs were partially paralyzed; but when, at our suggestion, he threw out either leg violently, it was evident that there was no loss of power in those members. To illustrate the unsteadiness of his gait, he attempted to walk across the room. This he accomplished slowly and with effort, his feet coming to the floor heavily at every step, and his whole body swaying from side to side. When he essayed to turn in his course, these symptoms were aggravated and others were presented. His arms joined in the general commotion, but his feet seemed rooted to the floor, as if unwilling to obey the order to turn. Finally, by a great effort, the feet were again called into action, and the patient managed, by making a considerable circuit, to face about and resume his walk. He complained of a persistent numbness and coldness in his arms, legs, and feet, and, on testing the cutaneous sensibility of the outer portion of the thigh with the æsthesiometer, it was found that two impressions were received, only when the points of the instrument were separated at least four and a half inches. He suffered much from acute neuralgic pains in the lower limbs that frequently impaired his rest, while at the best his sleep was fitful and unrefreshing. Sight and hearing were somewhat affected, and he was annoyed by a constant *tinnitus aurium.* While his appetite and digestion continued fair, his power of endurance had markedly decreased, so that a short walk of a couple of blocks was all that he felt able to undertake. His method of life for many years had been such as necessarily to operate injuriously against the healthful performance of the functions of both mind and body. As a circus-actor, his whole physical system had been racked and twisted into every conceivable shape, and as an associate of the dissolute of both sexes in the "profession," he had indulged freely in almost every conceivable form of dissipation. Some five years previously he contracted syphilis, and again two years after, when the secondary form of this disease manifested itself. When he commenced his visits to us, he called attention to several syphilitic ulcers on the left ankle. He had always indulged freely in alcoholic stimulants, and he had also used tobacco to the greatest conceivable excess, often smoking the whole day, and frequently rising from his bed at night to light his pipe or cigar.

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* Op. cit., p. 396.

The first application of the faradic current revealed a diminution of the electro-muscular contractility of the muscles of the legs, and the intensity of current which he could bear without discomfort was extraordinary. After the administration of a dozen applications of general faradization, we summed up their results as follows:—

1. The tactile sensibility of the thigh was increased, so that the æsthesiometer produced a sensation of two impressions when its points were separated but two and a-half instead of four and a-half inches.
2. The neuralgic pains of the limbs were completely relieved.
3. The extremities were sensibly warmer.
4. The electro-muscular contractility was normal.
5. Sleep was more sound and refreshing.
6. He was able to walk ten blocks with as much ease as he could walk two before, and the power of co-ordinating his movements was decidedly increased.

He continued treatment until January, a period of about four months, improving gradually until he was able to accept employment as clerk in the office of a coal-yard. Nine months after treatment was discontinued, he retained all that he had gained, and could readily walk a mile. His gait was somewhat unsteady, and he found it necessary still to carry his cane. Doubtless electrization had accomplished about all for him that it is capable of, yet it is possible that continued treatment might have still further benefited him.

We have stated that a prominent premonitory symptom observed in locomotor ataxy is pain of a neuralgic character. Some have described it as being more like rheumatic neuralgia, while in a few instances well-marked ataxy has been ushered in without any well-defined premonitory pain. Two of the six cases of this disease that we have treated by electrization alone presented at first such well-marked symptoms of muscular rheumatism that the attending physician of one of them, an intelligent and well-informed man, diagnosed this condition, and for several weeks treated the case accordingly.

Neuralgic pains that develop into well-marked locomotor ataxy—Deficiency in power of localization—Some improvement under general faradization.

CASE 94.—The patient was a young man aged thirty-three, and had served during several years of the late war as an officer in the Union Army. For several months he had complained of the severe aching pains in his legs, and ascribed them to the exposure and hardships of his recent army-life. His knees were stiff and lame, rendering him incapable of moving faster than a walk. In treating him by electrization, the applications were directed especially to the legs, the seat of the supposed rheumatism. This treatment, continued for two weeks, almost completely relieved the symptoms which had so persistently annoyed him, and thus in a measure seemed to confirm the diagnosis. For a short time the patient was apparently well, but in a few weeks the peculiar symptoms of ataxy manifested themselves, when he once more fell under our care. His movements then presented the characteristics of an advanced condition of locomotor ataxy. He found it difficult to rise from a chair, and even more difficult to start when he had gained his feet. His legs and feet were cold and profoundly anæsthetic. He was deficient in the power of *localization;* without the aid of sight he was unable to tell where his limbs were. Half a dozen applications of general electrization with the faradic current succeeded in giving very decided relief to the anæsthetic condition of the lower extremities, and improved considerably the steadiness of his gait.

Ataxy—Feeling of constriction in thigh—Neuralgic pains—Anæsthesia of feet and fingers—Some improvement under galvanization of spine and general faradization.

CASE 95.—A young Englishman, complaining of symptoms which, at first, masked the real disease from which he was suffering, was sent to us by Dr.

John Cooper, of Brooklyn. As junior partner in a large importing house, and having sole charge of the books of the concern, he had labored too hard, and had been confined too close to his desk. Up to the time of the onset of the symptoms, for the relief of which he was directed to us, he attended as usual to business. Regarding, however, his method of life as the cause of his difficulties, he immediately dissolved his business connections, and soon after fell under our observation. When walking or standing he leaned forward, and on attempting to throw his body into its natural erect position he complained of a sense of constriction in either iliac region, as if the muscles concerned in flexing the thigh were permanently contracted.

A general application, but directed especially to the lower portion of the abdomen and the groins, relieved him wonderfully, and another séance overcame completely this apparent muscular contraction, so that he was enabled to stand without inclining forward, and to walk with far greater ease. Now that this unusual complication was dissipated, the true character of his disease became evident. The more important symptoms of locomotor ataxy became unmistakably manifest :—

1. There was inco-ordination of the motor power in the lower extremities, but with no true paralysis there or elsewhere.
2. Characteristic neuralgic pains, of a sharp and shooting kind.
3. Considerable anæsthesia in the feet and fingers.

The patient was treated by galvanization of the spine, alternating with general faradization, but without perceptible improvement.

CHAPTER XXVI.

PROGRESSIVE MUSCULAR ATROPHY.[*]

THE disease termed Progressive Muscular Atrophy consists in a disturbance in the nutrition of the voluntary muscular system.

This atrophy, however, may be either partial or general. If partial, it is limited to the extremities, or a particular muscle or group of muscles; if general, it may involve nearly the whole muscular system.

The invasion of wasting palsy is so very gradual that it frequently exists for months before the patient is aware of any special loss of power. As a rule, the affection begins in the ball of the thumb or in the shoulder, and the first symptom of which the patient complains is a diminution of muscular strength.

The disease in its progress is subject to varying periods of seeming arrest, and not unfrequently it may remain stationary for many years.

Sooner or later, however, the emaciation extends to the muscles of the hands and forearm, and the loss of power in these members corresponds exactly to the atrophy. In extreme cases complete immobility of a limb is produced. This condition, however, is rarely met with. In certain formidable cases the atrophy successively invades the breast, the buttocks, and even the muscles of respiration; and finally, death by suffocation is the result.

The muscles of mastication and those which move the eyeballs are the only ones which have not been known to be attacked.

Diagnosis.—The diagnosis of muscular atrophy is not usually difficult, although it is possible to confound the partial form with lead palsy and paralysis from injury to a motor nerve.

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[*] On account of the unsettled nature of its pathology, this disease is presented by itself, instead of under the head of Central Paralysis.

The simple existence of atrophy is not sufficient ground for diagnosis, since it may occur in many forms of paralysis.

From paralysis from this latter cause, and from ordinary central paralysis, wasting palsy is readily distinguished by the "DISSECTING character of its march."

It attacks special muscles, and thus causes a characteristic deformity, which in the hand is so marked and peculiar that it has been termed by Duchenne the "*main en griffe*," or claw hand. The claw-hand is thus explained:—The *extensor communis digitorum* only acts on the first phalanges, while the second and third phalanges are extended by the *inter-ossei* and *lumbrici*, which adduct and abduct the fingers. The *flexors sublimis* and *profundus* act on the second and third phalanges, while the *inter-ossei* act on the first.

When now the inter-ossei are paralyzed, the first phalanges cannot be independently flexed, and the other phalanges are drawn into the hand by the flexors *sublimis digitorum* and *profundus*, and bring with them the first phalanges. The *extensor communis*, being now no longer opposed by the antagonistic action of the flexors of the first phalanges, brings them backwards. The second and third phalanges are kept flexed by the *flexors sublimis* and *profundus*, because, on account of the paralysis ot the inter-ossei, they have no extensor.

Among the symptoms that point to muscular atrophy are *fibrillary** *contractions*, changes of nutrition in the bones and joints, and neuralgic pains of a certain character, and anæsthesia.

Another point in the diagnosis is that it may confine itself to certain muscles or even parts of muscles.

Wasting of tissue from injury to a nerve is limited to the exact parts supplied by that nerve, and in central paralysis the loss of power is invariably out of proportion to the extent of atrophy observed. In lead palsy the invasion is sudden, and the distinctive features of lead poisoning, viz., colic, blue line on the gums, tremblings, pallor, etc., usually indicate the character of the affection.

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* This term is applied to involuntary spasmodic twitchings of parts of muscles.

The pathology of this disease has been a matter of considerable discussion. The morbid lesion that is sometimes found is atrophy of the anterior roots. Atrophy of the sympathetic has been found in three cases. Gray degeneration has been found by Virchow, Rokitansky, Gull, and Dumenil.

The disease may be complicated with locomotor ataxy and other nervous affections.

The disease appears to be *caused by catching cold after great physical exhaustion;* therefore, it is more frequent among the laboring classes. So far as we are able to judge from our opportunities for comparative observation, muscular atrophy, like locomotor ataxy, is more frequent in England, France, and Germany, than in America. The causes of this difference are the depressed condition of the laboring classes in Europe, and probably also the greater moisture of the air.

Electro-diagnosis.—Electro-muscular contractility is either diminished or destroyed. Electro-muscular sensibility is usually diminished. Various changes in irritability may take place during the progress of the disease.

Reflex contractions occur in muscular atrophy. *Diplegic contractions* also appear in this disease. These facts, taken in connection with the history of the case, the atrophy, the fibrillary contractions, swellings, and anchylosis in the bones and joints, the anæsthesia and the neuralgia, make up the diagnosis. Diplegic contractions were first observed in muscular atrophy by Remak.

The disease does not always exist alone ; it may be complicated with locomotor ataxy in paralysis of the cranial nerves and other disorders of the brain.

Treatment.—General and localized faradization and galvanization, and also galvanization of the spine, and especially of the *sympathetic.* In our limited experience with this disease we have seen suggestive results from galvanization of the sympathetic.

The *prognosis* under these various methods of treatment is sometimes moderately favorable, but frequently the reverse. Duchenne reports a case that was successfully treated by faradization. Althaus* records a very remarkable result obtained by galvanization of the sympathetic. It would appear, therefore, that cases of this disease are by no means entirely hopeless.

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* Op. cit., p. 535.

If only one member is attacked—if there be no hereditary predisposition to the disease, and the electro-muscular contractility is not very decidedly impaired—we may reasonably expect much benefit from the persistent use of localized electrization with the faradic current. In connection with the electrical treatment we may employ warm and sulphur baths and methodical exercise.

PROGRESSIVE MYO-SCLEROSIC PARALYSIS (PROGRESSIVE MUSCULAR HYPERTROPHY), PSEUDO-HYPERTROPHIC PARALYSIS.

This disease of childhood was first described by Dr. Edward Meryon, in a paper read before the Royal Medical and Chirurgical Society, December, 1851.* A case was subsequently reported by Dr. T. King Chambers, in the Medico-Chirurgical Transactions, 1854. The disease has been observed in two, three, and four children of one family.† The disease has been systematically studied by Duchenne, who was the first to set it before the profession as a distinct disease. The *symptoms* of this affection in the first stage are weakness in the lower limbs and flexion of the toes; in the second stage, *increase in size of the muscles of the legs*—especially of the calves, of the back, and of the gluteal muscles; in the third stage, extension of the disease, muscular atrophy, exhaustion, and death.

Electro-diagnosis.—Farado-muscular contractility usually diminished; galvano-muscular contractility may be either normal or exaggerated; electro-muscular sensibility is sometimes diminished, sometimes normal.

The disease is supposed to be one of the sympathetic nerve.

Prognosis.—The patient is pretty sure to die in the course of a few years. In the second stage the symptoms may remain stationary for a long time. Benedikt was able to improve a case of two years' standing by galvanization.

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* *Vide* the article on this subject by Meredith Clymer, M.D., in the second American Edition of Aitken's Practice of Medicine, 1868, p. 980; also, Lecture by Dr. Clymer, in Medical Record, July 18th, 1870.

† Recently, two cases of this disease, in the same family, have been admitted to St. Luke's Hospital.

Treatment.—Faradization and galvanization of the affected muscles, and galvanization of the sympathetic, should all be tried in succession or alternation.

CHAPTER XXVII.

SPASMODIC DISEASES.

Writer's Cramp.—This affection is characterized by a kind of paralytic or spasmodic condition of the muscles of the hand that are employed for any special purpose. It is not peculiar to writers. It may attack seamstresses, milk-maids, and others whose callings compel them to use for a long time a certain set of the muscles of the hand. It may be caused also by rheumatism, inflammation of the radial and ulnar nerves, and psychical influences, as well as by disproportionate exercise of certain muscles.

It is believed that the affection is not always purely peripheral, but that it frequently is connected with disease of the upper portion of the spinal cord.

It seems to differ but little from certain other spasmodic conditions, such as wry neck and histrionic spasm.

Whether found in the artist, rendering him unable to manipulate his brush—the pianist, preventing him from fingering his instrument—or the penman, causing his writing to be almost if not quite illegible—the same general characteristic is observed, viz., the recurrence of spasm whenever an attempt is made to execute a special movement. The peculiarity of this spasmodic action consists in the fact that it does not follow other movements of the affected part.

The *treatment* should be both central and peripheral. Galvanization of the upper portion of the cord and of the median and radial nerves, spinal cord, plexus, and nerve-currents—and faradization of the affected muscles and of their antagonists, may be tried.

The *prognosis* in the early stages is sometimes favorable for a perfect cure ; advanced stages of long-standing cases are usually rebellious; but even these may be much relieved. *Rest from the occupation is almost imperative.*

Unfortunately, however, those who are most frequently subject to writer's cramp are the very ones who are unable to take the necessary rest.

Although the results of treatment by electrization in this variety of palsy is by no means uniform, yet it has undoubtedly been followed in many instances by approximate and even perfect recoveries.

Our own experience and success in its treatment has not been very large. Of three cases we have treated, one was decidedly benefited; the others were not benefited. Other observers, especially Meyer, have been more successful.

Writer's cramp, existing for four years—Improvement under faradization and galvanization.

CASE 96.—For a year the patient had observed a certain loss of power in the thumb and index finger of the right hand, that became more decided and annoyed him more and more seriously, so that about a year previous to his visit to us he was enabled only with difficulty to write the few pages every day his business required.

The patient was unable to fully extend the thumb and index finger, and on localizing the faradic current through the flexor longus pollicis and the adductor pollicis, there was a marked decrease in the electro-muscular contractility. The flexors and extensors of the other fingers responded normally to the influence of the current. The inner surface of the hand was decidedly anæsthetic, while he complained of a constant soreness of the wrist that at times became quite painful.

We began with the faradic current, localizing it through the two muscles of the thumb specially affected, and also making the application more general through arm, wrist, and hand.

This method completely dissipated the annoying anæsthesia and soreness of the wrist, but resulted in no other benefit.

A mild galvanic current from six Bunsen's cells was more effectual. Twelve applications resulted in a considerable increase of strength in the affected hand, and the flexor muscles of the thumb and index finger very decidedly relaxed, so that he was readily enabled to accomplish two or three times more in the way of writing than before.

CHOREA.

Chorea, in its generic signification, includes such a wide range of nervous conditions, and has for its predisposing cause such a variety of pathological states, that it is very properly differently named, as it belongs to either this or that pathological genus.

Since the time of Sydenham, who gave the first scientific description of its symptoms, the most common choreic movement has been called St. Vitus's dance. This name of itself signifies nothing. It refers to an ancient tradition that St. Vitus possessed the power of curing this choreomania, and actually relieved those who sought his aid. Yet it does not seem to be an unfortunate designation, for pathological anatomy teaches so little as to the material alteration of the nervous centres, that we seek in vain for a scientific name, and the morbid condition to which the term St. Vitus's dance is now applied is so well understood, both by the profession and the laity, that it answers a better purpose than any name constructed with the most scientific accuracy.

The peculiar symptoms of this disease almost invariably occur in early youth, and parents when they first observe the characteristic twitchings in the movements of their children are often unnecessarily alarmed.

It is a fact well recognized, that the majority of cases of this simple choreic disturbance recover in from six weeks to two months, if left wholly to the efforts of Nature, and no matter what course of treatment is adopted, the cure is but little accelerated.

Chorea can be partial or half sided.

Causation.—The great predisposing cause of chorea is the nervous diathesis, since it most frequently attacks those children who derive nervous constitutions from their parents. The disease is excited by almost any influence that either greatly weakens the nerves or makes a sudden and powerful psychical impression. It is probable that it may arise from taking cold. The observed relation of chorea to rheumatism may perhaps be explained by the fact that an attack of rheumatism at a tender age exhausts the system and excites the choreic manifestation.

Electro-diagnosis.—In chorea electric examination often reveals increased motor irritability, and (according to Benedikt) "opening contractions with weak currents."

Choreic patients are usually in a condition of hyperæsthesia. Feeble electric currents are not only sensibly but painfully felt over the entire surface of the body. The spine is especially sensitive. In one case of chorea we observed cerebral anæsthesia: powerful currents could be borne on the top of the head without discomfort.

Treatment.—Chorea has been successfully treated by a variety of methods of electrization—by frictional electricity,* peripheral faradization,† and central galvanization,‡ and in our hands general faradization. Successful results have been gained by all these methods. We have found general faradization alone so uniformly successful in cases of general chorea, that we have but rarely had occasion to experiment with other methods, and when we have alternated the use of central galvanization we have not thus far been satisfactorily rewarded. Our success with general faradization in chorea is probably to be accounted for partly by the muscular exercise that is derived from this method of treatment, as well as by the tonic action of the current on the nervous system. Choreic patients do not usually bear strong central galvanization or protracted sittings; the milder influence of the faradic current is preferable to the galvanic, unless the latter is used with considerable caution. Benedikt claims to have been uniformly successful in more than twenty cases of chorea by galvanization of the spine. He used, however, but a small number of elements, and the length of the sittings was not more than one and a half minutes. Other observers have not been so successful with this method. Meyer reports unsatisfactory results with galvanization of the spine in two or three cases.§ We have not yet succeeded in verifying the experience of Benedikt in two instances in which we tried it; in one its results were negative; in the other it increased the symptoms and neutralized all the good that had been obtained by general faradization. It is probable that the success of Benedikt with galvanization of the spine was due to the very great caution which he exercised in regard to the strength of the current and the length of the sittings, as he himself declares that the symptoms were aggravated if the number of elements were much increased. For hemi-chorea Benedikt recommends galvanization of the head. We prefer for all cases of chorea general faradization, occasionally varied by central galvanization, with very mild currents, and believe that this method of treatment faithfully used will do all that can be done for this disease through electricity.

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* Dr. Gull. Frictional electricity was also used for chorea in the last century, and it was claimed with success.

† Duchenne and Becquerel.

‡ Benedikt.

§ Op. cit., p. 364.

Prognosis.—The prognosis of general idiopathic chorea is almost always favorable. Aside from the well-known fact that many cases recover spontaneously in the course of a few weeks or months, direct and positive results of treatment can be appreciated in this disease more uniformly than in any other spastic condition. Cases of failure are exceptional. The worst cases, when recent, sometimes seem to yield better than those which are comparatively mild.

Partial chorea, affecting the eyelid, the muscles of the neck, or a single limb, or group of muscles, is more obstinate than a much worse form of general chorea. The explanation of this inconsistency is that patients affected with partial chorea are apt to delay weeks, months, and years before taking treatment. Recent cases we have found to yield almost uniformly. All long-standing choreic cases need to be treated perseveringly—from two to six weeks being usually necessary to complete a cure. Symptomatic chorea—dependent on cerebral or cerebellar disease—offers an unfavorable prognosis.

We have treated 13 cases of chorea, with the following result:—

Recovered	8
Approximately recovered	1
Slightly benefited	2
Not benefited	1
Unknown	1

Choreic disturbance of the right side of the face, in a lady 18 years of age, existing since childhood—Recovery for one year follows the local use of the faradic current.

CASE 97.—Miss K., aged 18, applied to us, by the advice of Dr. H. Gregory, for the relief of a choreic disturbance of the right side of the face and eye, that had annoyed her since childhood. Her general condition was decidedly nervous; but as objections were made to general treatment, the applications were necessarily local. A dozen sittings with the faradic current resulted in considerable relief to the face; but soon after the cessation of treatment the choreic disturbance rapidly disappeared, and for a year ceased to annoy her.

A second attack was decidedly ameliorated by the same method of treatment.

In consideration of the fact that the difficulty with this patient was of life-long standing, it may be considered fortunate that even the slightest relief was afforded.

It is probable that general treatment would have been followed by complete recovery.

Chorea of a very severe character in a lad of eight years—Impossibility of lying or sitting—Loss of speech—No results from medical treatment or galvanization of the spine—Recovery under general faradization.

CASE 98.—A little boy, aged 8 years, and suffering from chorea, was brought to us for treatment June 11th, 1868. His symptoms were of the following aggravated character: The arms, legs, and face were in almost constant motion. It was impossible for him to stand alone or even sit upright. The involuntary movements were so rapid and violent that it was unsafe to leave him alone on a bed or sofa, for fear that he would throw himself from it. The power of speech was entirely gone. The appetite was poor. Sleep was possible only after an anodyne draught.

These symptoms as described had existed for one month.

Some two months previously his attendants had noticed that many of his movements were strange and uncertain, but little notice was taken of the fact. The exciting cause of the severer symptoms was excessive fright at night, when alone in the house with a servant. The treatment by medication had been judicious and persistent. We confined ourselves to the use of the faradic current, since a trial of the galvanic aggravated the symptoms.

The immediate effect of general electrization was very decided. In one week, during which three applications had been given, the little patient was enabled to sleep quietly through the whole night without the administration of an opiate. The power of speech gradually returned, the appetite improved, and the choreic disturbance notably diminished until the middle of July, when we pronounced him approximately cured. A few weeks' recreation in the country completed the restoration.

Severe chorea in a girl seven years of age—Less than usual sensitiveness on the head—Recovery under ten general faradizations.

CASE 99.—L. J., a girl seven years of age, was brought for treatment by general electrization in September, 1868. She was pale and slender, but for her age quite tall. For the last eighteen months her growth had been remarkably rapid, and to this fact the mother was inclined to attribute the disease. The parents first noticed some twitching of the left hand in the fall of 1866, but did not at the time give it particular attention. The choreic symptoms rapidly increased to such an extent, however, that they became alarmed, and applied for medical treatment. But in spite of persistent internal medication, the want of power to co-ordinate her movements grew more marked, and the symptoms extended to her limbs and organs of speech. At the time that the patient came under our notice the choreic movements were quite violent. The left side was considerably more affected than the right, and her articulation was so indistinct that it was impossible for a stranger to understand what she said. We found no difficulty in inducing the child to submit to the treatment, but the involuntary agitation of the legs was so great that it was found necessary to hold the feet upon the plate to which the negative pole was attached.

The current was very sensitively felt over the stomach, but not over any other portion of the body. It may be remarked, however, that over the head could be borne without discomfort a current much more intense than is the case in the normal condition.

The first and second applications resulted in no appreciable change in her symptoms; but at the fourth visit, about ten days after the first, a perceptible improvement was noticed. As is usually the case when a favorable result follows any method of treatment, the diminution of the choreic movement was *first manifested in the lower limbs.* The progress towards recovery was not very rapid.

At the fifth visit she could retain her feet upon the plate by her own unaided efforts, while the application was being made. This improvement had also extended to the arms and face, and the tenth application, administered about a month after the first, dissipated every choreic symptom. There was one peculiar and well-marked feature, which we observed in this as well as in several other cases. We refer to the intensity of the current used when applications were made to the head. As the disease advanced toward recovery, such applications became more and more painful, so that it was necessary to gradually decrease their power.

The beneficial effects from the use of this agent in the treatment of chorea are not as a rule immediately manifest. The same is true of every other curative remedy enployed in this disease. It seems to be necessary that a certain impression should be made upon the nervous system, and when that point is reached, recovery is often extremely rapid.

However much we may doubt the statement that the nervous temperament is favorable for the development of chorea, we cannot ignore the fact that hereditary predisposition is a frequent cause. In families where this predisposition is manifest, the tubercular or scrofulous diathesis frequently exists, and according to the researches of Dr. See, of France, physician to the "Hôpital des Enfants," it would seem that rheumatism, as a predisposing pathological state, was unquestionable.

He states that in almost every case rheumatic pains had been complained of; and although pre-existing rheumatic affections have been noticed quite frequently by others, it must not be forgotten that lumbago and various muscular pains often precede the invasion of chorea as an effect and not as a cause. An hereditary tendency to insanity has been noticed as existing in families in connection with chorea. An instance of this kind has fallen under our observation :—

Choreic convulsions in a lady 50 years of age—No improvement under general faradization.

CASE 100.—The patient was a lady, aged 50, who had for a number of years been afflicted with convulsions that closely resembled chorea. Her voluntary motions were somewhat under control, even when the symptoms of her disorder were most marked. When walking across the room her arms would suddenly become convulsed, while the power of locomotion remained unimpaired. At other times she would stagger, and yet be able to co-ordinate perfectly the movements of her arms. Her intellect was somewhat impaired, and was evidently becoming completely obscured, as had been the case with a sister who had died insane, and a niece who is at present in an asylum.

The patient was treated perseveringly by general electrization, but with no good results. The central nervous system was possibly in a condition of *sclerosic* degeneration (see p. 406).

Mild chorea, mostly unilateral—Recovery under three general faradizations.

CASE 101.—L. A. was brought to our office during the last summer, suffering from St. Vitus's dance of a mild character. About six weeks before we saw her, the choreic movements became manifest in her face and arms. It simulated somewhat the rare form of disease denominated hemichorea. It was not completely unilateral, however, for though the irregular nervous movements were mostly confined to the left cheek and arm, some occasional twitching was observed in the right side. The case was evidently of that mild character which is readily cured by the use of internal remedies or by unaided Nature.

She was, however, submitted to the influence of general electrization, and the rapidity with which the choreic movements were dissipated was a striking example of its power. But three applications were given, and these were administered within the space of a week. There was manifest improvement the day after the first visit, and after the third operation the control over every movement was normal. Treatment was then discontinued, and no relapse has yet followed.

Chorea of face and arms in a lad 12 years of age, dependent on mental influences—Recovery under localized faradization.

CASE 102.—In December, 1866, a lady brought to us a little boy, aged 12 years, to be treated for symptoms that were somewhat anomalous, yet not of a character sufficiently marked to enable us to say positively that St. Vitus's dance proper existed. While in perfect repose, and even when engaged in play, study, or conversation, if there was nothing to excite or alarm, he exhibited nothing unusual in his movements. If, however, he failed in his recitations, was scolded by his parents, or if he became excited in his play, or was abashed by the notice of a stranger, some peculiar symptoms became immediately manifest. The muscles of the face became convulsed, and at times the twitching was quite violent, so that his appearance was grotesque in the extreme. Rapid contractions of the muscles of the arm also occurred. These were most noticeable in the biceps and flexors of the hands and fingers.

The child was to all appearance perfectly healthy, and was of a lively and genial disposition.

This disorder of the nervous function had existed some four or five months, so that considerable uneasiness was excited in the minds of the friends of the patient. As he lived a considerable distance from the city, applications were given only occasionally, as his attendant found it convenient to bring him. During the course of a month the boy visited us some five or six times, and as he was suffering from no debility, we judged it to be sufficient to make the applications only to the parts affected, and not to extend them over the whole surface of the body. The result of this irregular treatment was successful, since all the abnormal movements to which he had been so readily liable on exposure to any excitement became less and less marked. At the end of the month he left us cured.

An aggravated case of chorea resists the action of the galvanic, but yields to general electrization with the faradic current—Relapses and again recovers under the same treatment.

CASE 103.—A little patient, aged 10 years, under the professional care of Dr. J. O. Farrington, presented the severest symptoms of chorea.

Prof. George T. Elliott was called in consultation May 18, 1868, and by these gentlemen electrical treatment was advised.

Some two months previous to the consultation certain abnormal movements —such as starting suddenly to his feet, throwing out a hand or a foot, etc.— were observed by the teacher of the boy. Two weeks subsequently, the patient was seized with well-marked choreic symptoms of the right side of the body, and in two days the disturbance extended to the opposite side. So constant and violent were the movements of his arms and legs that it was impossible to keep him on a bed or sofa. It was necessary to place him on the carpet, surrounded by inflated rubber bags. Intelligence seemed to be perfect, but the power of speech was lost, and the sufferer made known his wants by impatient cries and ill-directed motions.

Sleep was impossible without the nightly administration of an opiate Contrary to our judgment, but by suggestion, we commenced treatment by the use of a mild galvanic current directed especially to the base of the brain and the spinal tract; but this method served only to aggravate the child's condition. We then resorted to the faradic current by the method of general electrization, but so violent were the involuntary movements in the limbs and body of the patient, that it was with difficulty that he could be held in a sitting posture and his feet kept on the copper plate to which the negative pole was attached. The applications were *general*—every portion of the body, from the head to the feet, being influenced on each occasion.

Improvement was manifest from the very first. He was at once enabled to sleep soundly, although his opiate was reduced one-third, and after the fourth application it was dispensed with altogether. In the course of three weeks, during which time fifteen applications were given, the case was so far improved that the patient was able to utter distinctly words and sentences. The choreic symptoms were so much diminished that the boy could readily sit quiet and alone, and during an application was able to command the movements of his body and feet. Improvement continued during the administration of a few more applications, when the child was taken to the sea-shore, where in two weeks he quite recovered. Some three months since, after having enjoyed excellent health for a year and a-half, the boy suffered from a second attack. He was immediately subjected to the influence of electrization, and recovered even more rapidly than before.

TORTICOLLIS—(WRY-NECK).

This familiar disease consists in a spasm of the muscles of the neck, by which the head is drawn to one side. The spasms may be tonic or clonic.

Although the pathology of the disease is obscure, it is yet quite clear that it is of a nervous character. More than by other cause, it is brought on by excessive mental labor or anxiety. The symptoms usually come on gradually; the muscles of the neck on the side toward which the neck is turned are sometimes flabby and atrophied, and the muscles on the other side are hard, lumpy, and enlarged. Frequently the deeper muscles of the neck are involved, as well as the sterno-cleido-mastoid and trapezius. The spinal accessory nerve would appear to be at fault. The condition is really *a kind of "partial chorea," analogous to writer's cramp, facial spasms, spasm of the eye-lid,* and, like all these, is usually very obstinate, except in the mild form and early stages. *The disease is frequently brought on by excitement or worry.*

Diagnosis.—The disease should not be confounded with common *stiff neck* that is caused by rheumatism of the muscles of the neck and is analogous to lumbago. In stiff neck, which usually yields to faradization like other forms of myelgia, the head is kept from moving by the pain which movement causes. Diseases of spine and diseases of the brain sometimes produce tonic spasms of the muscles of the neck that resemble torticollis.

Electric examination.—On the affected side * the muscles sometimes exhibit increased electro-muscular contractility and sensibility. On the other side the electro-muscular contractility is sometimes diminished.

Treatment.—Galvanization of the muscles of the affected side with mild currents, and faradization of the muscles of the other side, galvanization of the sympathetic and cervical spine, are the methods that should be tried in this disease. They may be tried simultaneously or in succession.

Protracted applications are not ordinarily indicated in this affection.

General treatment is only required when the patient is debilitated.

In connection with the use of electricity, the hypodermic injection of morphine, and counter-irritation of the cervical spine by blisters, and mechanical contrivances for keeping the head in position, may be tried.

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* It should be considered that the sterno-cleido-mastoid, as it pulls the back of the *head toward the shoulder, turns the face in an opposite direction. The face therefore is turned away from the affected muscle.*

Prognosis.—In the early stages torticollis may be relieved or cured by electrical treatment alone. After it has been established for a number of months, it becomes one of the most intractable of diseases. Even when relieved by treatment, it is much disposed to relapse. No case should be abandoned until both galvanic and faradic treatment has been thoroughly tried, since it is the only method of treatment that offers even any hope; and the physician should not be discouraged if the symptoms appear to be aggravated by the first few applications, but should reduce the strength of the current and the length of the séances. The same remark will apply to analogous diseases, such as writer's cramp and facial spasm.

Torticollis of long standing, brought on by over-confinement and anxiety—Some relief from faradization and galvanization.

CASE 104.—Mr. K——, aged 40, was sent to us June, 1870, by Dr. Willard Parker. For several years before the attack appeared he had been in his usual health, but had been severely confined and much distressed by the cares of business. The symptoms appeared gradually; they were at first slight, and only developed their full force after several weeks. When we first saw him he had been suffering for several months. His face was almost constantly turned toward the left side. On the opposite side the sterno-cleido muscle was considerably hypertrophied, and on the other flabby. The position of his face and the violence of the cramp were much dependent on mental influences, being aggravated by exhaustion or worry.

Electric examination showed increase of electro-muscular contractility in the affected side, and diminution on the opposite side (towards which the face was turned). Careful examination revealed no evidence of disease of the vertebræ.

The patient was *treated by stable galvanization of the hypertrophied and hardened muscle, by spinal-cord brachial plexus current, by galvanization of the sympathetic and spine, and by faradization of the flabby muscles of the opposite side, and by general faradization.* In three weeks there was positive but not marked improvement; there was decrease of the hypertrophy of the muscle and some diminution of the spasm.

As is so often the case, the patient appreciated the benefit of the treatment after resting for two or three weeks, even more than while receiving the application. Unfortunately the very sudden death of a near relative severely shocked his nervous system, and caused a relapse of the torticollis.

PARALYSIS AGITANS (SHAKING PALSY).

There are two kinds of shaking palsy:—

1st. *Those with discoverable organic lesions.*

This condition is believed to depend on degeneration or induration of the central nervous system; the degeneration may be in the cervical portion of the spinal cord or in the brain, and especially in the part near the pons.

2d. *Those where no lesion can be discovered.*

These are usually styled functional, although, like hysteria, they may be supposed to depend on some molecular derangements which are not revealed to the microscope.

The disease may be local or general; it may attack one limb, or the lower jaw, or all four extremities.

It is most frequent in the aged, but is sometimes observed in middle life, or in the young. In the clinic of Duchenne (Paris) we saw a typical case of shaking palsy in a child two years of age.

Treatment.—Central galvanization and general faradization, for general effects, may be used in shaking palsy with benefit. The best results have been obtained by galvanization of the spine and sympathetic and brain.

Prognosis.—Cases where all the limbs are affected are never cured by any method of treatment, especially in the aged. Cases in which only one limb, or one upper and one lower limb are affected are sometimes benefited, and in rare instances cured. Temporary relief can sometimes be obtained where no permanent benefit results. The tremor of the limb is sometimes abated or completely arrested for one or more hours after the application *either of general faradization* or *galvanization of spine*, and in rare cases entire recovery occurs. Dr. Russell Reynolds has reported a cure by the galvanic current. Recently Jules Chéron, of Paris, has published the results of galvanization in 7 cases. Of these 2 were cured; 2 were much improved; and 3 were much improved in their general condition, but not in the tremor.

Palsy agitans, complicated with right hemiplegia, coming on gradually during a season of overwork—Both hands affected with tremor; diminution in size of the right leg; insomnia and nervousness—Temporary calming and strengthening effect from general faradization—No benefit from galvanization—No permanent relief of the palsy agitans.

CASE 105.—Mrs. F., aged 66, of strong frame and capable of great exertion, while very busily engaged in service for the Sanitary Commission in 1862, was attacked by slight symptoms of disease of the central nervous system, which eventuated in decided hemiplegia of the right side. This was followed in the course of time by palsy agitans, that extended to both upper and lower extremities.

We first saw the patient May 17, 1869. She was then quite helpless and dependent; was assisted in going to and rising from her bed. The shaking of the hands was constant, except during sleep, on which, however, she could not depend.

Electric examination.—Slight diminution of electro-muscular contractility and sensibility in the muscles of the right leg, with some anæsthesia.

The right leg above the knee was smaller than the left by half an inch.

The patient had been much relieved in her general symptoms, though not in shaking, by general faradization. We continued for two weeks the same treatment, with temporary benefit. The patient usually experienced to a very pleasant degree the temporary calming and tonic influence of the applications.

Galvanization that we subsequently employed did not seem to be as satisfactory in its effects.

We have succeeded in suspending the tremor in one case of palsy agitans, for two or three days, by general galvanization.

Among the many forms of tonic and clonic cramps for which galvanization and faradization are of essential service, may be mentioned:—

MUSCULAR CONTRACTIONS.

These may arise in hysteria, in myelitis, meningitis, and spondylitis, diseases of the cerebrum and cerebellum, or they may be of a reflex character. They exist sometimes in neuritis or rheumatism.

The *treatment* consists in peripheral galvanization or faradization of the affected muscles or of their antagonists, with stable currents and galvanization of the head, spine, and sympathetic, according to the special indications.

The *prognosis* is usually unfavorable for all except the rheumatic cases.

FACIAL SPASM.

This affection, which is not unfrequent, is usually very obstinate against all treatment. The treatment is galvanization with the spinal-cord-muscle or nerve-muscle current. Recent cases may be cured by the application of the galvanic current to the branches of the fifth pair. Long-standing cases may be temporarily relieved, but are rarely permanently cured. Remak reported success even after the condition was very chronic.

DYSPHAGIA FROM SPASMS OF THE PHARYNX.

This symptom, though sometimes the result of organic central disease, is not unfrequently of a purely spasmodic character, and as such is amenable to electric treatment, either by external or internal applications. The method we adopt for such cases is to place one pole on the back of the neck and the other just above the sternum, or by the inner border of the sterno-cleido-mastoid muscle. If this method fails, internal applications may be made, by means of a catheter-shaped electrode, against the opening of the œsophagus. Some cases yield with surprising readiness to external treatment. Cases dependent on central disease are usually quite rebellious.

A case of this kind, in which the food was returned through the mouth or nose, was cured by Hiffelsheim by galvanization.

Hiffelsheim has recorded a case of excessive and obstinate vomiting that was cured by five applications of the galvanic current to the pneumogastric.

SINGULTUS (HICCOUGH).

This symptom, when it becomes permanently annoying, might be treated by *galvanization of the sympathetic and pneumogastric.* (Fig. 41, p. 176.)

TREMORS.

Tremors caused by lead poison, by alcohol, or by mercury, and by the various cerebral affections, do not offer a very favor able prognosis. Some of the cases from these causes simulate palsy agitans.

TETANUS.

Dr. Mendel has reported two cases of tetanus successfully treated by the galvanic current. He used various methods of application, central and peripheral. Immediate relief followed each application.

The conclusions at which he arrives from his cases are that a mild current should be applied to the affected muscles, without regard to the direction of the current, although the positive pole should be applied to the antagonists.

HYDROPHOBIA.

Schivardi (quoted by Benedikt) treated a case of hydrophobia by galvanization continued for eighty hours. The current was directed from the feet to the forehead. The symptoms were alleviated, but the patient died.

STAMMERING.

Dr. Althaus succeeded in curing a case of stammering of five years' standing, in a lad nine years of age, by the application of the galvanic current to the laryngeal nerves. The applications were made twice a week for two months.

EPILEPSY.

Epilepsy is one of the diseases for which electricity in some form or other has been used for many years, though with rather uncertain and capricious results. The method of treatment that promises most in this disease is galvanization of the sympathetic, and perhaps also of the head and spine. Another method is to place one of the poles over the point whence the aura proceeds, and the other over the nerve-centre. Local treatment may be advantageously combined, in case of debility, with general electrization.

This treatment is now considerably employed, and occasionally with positive results. The subject demands rigorous and patient investigation. Epilepsy of the hysterical variety offers a field of considerable promise for the observation and study of those who use electricity in the treatment of disease.

Prognosis.—Temporary relief can be obtained in very many cases of epilepsy by electrical treatment. The intervals between the attacks can be greatly lengthened, and in a certain proportion of the cases the results are believed to be permanent.

Althaus* states that of 64 epileptics that he has treated by galvanization, in only two did it prove to be injurious, while in the large majority of cases immediate benefit was perceptible. How permanent the result would be, he was not able to judge.

Of 6 cases that we have treated, 2 were decidedly benefited, 2 were slightly benefited, 1 was not benefited, and in 1 case the result is unknown.

Petit mal—Marked temporary relief from general faradization and galvanization of sympathetic—Relapse.

CASE 106.—In one case of "petit mal" occurring in a boy some 13 years of age, the bromide, given in doses of 10 grs. three times a day, acted charmingly. The paroxysms, which for nearly two years had occurred from six to ten times a day, were immediately reduced to one, two, and three in the twenty-four hours.

This improvement was manifest for nearly a month, when, notwithstanding the increased doses of bromide, the paroxysms gradually increased in frequency, until the patient was rendered unconscious by them as often as before. We now resorted to general electrization with the faradic current, and occasionally to galvanization of the sympathetic. Singularly enough, the results that followed were substantially the same as those obtained from the administration of the bromide of potassium. For a few weeks the frequency of the epileptic seizures was reduced to one and two a day, when, notwithstanding every effort, there was a second relapse to his old condition.

The boy evidently inherited a very decided nervous diathesis, but the exciting cause of the attacks was ascribed to a severe fall some weeks before the manifestation of the first paroxysm.

Epilepsy of eleven years' standing—Periodical attacks—Improvement in sleep and mental condition, and diminution of attacks under general faradization. Nothing further gained by galvanization.

CASE 107. W. H. V., a lad aged 16, began first to suffer from epileptic seizures when but five years old.

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* Op. cit., p. 521.

For the first five years the attacks, consisting of a number of fits in rapid succession, occurred every five or six weeks. From his eighth to his fifteenth year the paroxysms increased in frequency and severity, until, at the date of his visit to us, the attacks recurred every week.

It was a noticeable fact that for the last year the patient had almost invariably suffered from these epileptic seizures on Saturday.

The boy had grown sensibly weaker both in mind and body, and was excessively irritable and capricious.

Treatment was commenced by general faradization, with special reference to the head and spine.

Under this treatment sleep became more sound and refreshing, and the mind calmer, while the usual paroxysm was delayed until the Thursday following the regular time for its recurrence. The general condition of the patient continued to improve, and a second attack was delayed four weeks. He remained under observation some months longer, having a paroxysm (far less severe, however, than formerly) about every four weeks. The galvanic current, variously used, seemed to accomplish nothing that had not already been obtained by the faradic. The case soon after passed from our care, and whether relapses have occurred we have not been able to ascertain.

DISEASES

OF

SPECIAL ORGANS.

CHAPTER XXVIII.

DISEASES OF THE ORGANS OF DIGESTION.

AMONG the diseases of the organs of digestion for which electrization has been successfully employed are ***dyspepsia***, ***gastralgia***, ***vomiting*** or ***regurgitation***, ***jaundice***, ***constipation***, ***chronic diarrhœa***, and ***abdominal neuralgia***.

These symptoms may be divided into two classes—those which depend on actual and recognizable disease of the organs, and those which are of a nervous character. Dyspepsia, gastralgia, and vomiting may arise from weakness, congestion, inflammation, ulceration of the stomach; jaundice from a variety of morbid states of the liver: constipation and chronic diarrhœa, and abdominal neuralgia, from disease of any or all of the organs of digestion, from the stomach to the intestines.

On the other hand, all of these symptoms may exist independent of any recognizable disease of the respective organs. Such cases are to be classed among the nervous; they occur usually in nervous constitutions, and are symptomatic of disease of the nerve-supply of the organs, of the spinal cord, of the sympathetic, or of all combined.

These two general types of disease are sometimes associated.

Electro diagnosis.—Irritable conditions of the stomach, liver, and intestines are sometimes revealed by their sensitiveness to the electric current. Pains must be taken to distinguish the sensitiveness of the skin from that of the internal organs.

An anæsthetic condition of the liver is sometimes exceedingly marked. In two of our cases the whole power of our faradic apparatus was not painfully felt, when localized through the liver by large sponge electrodes.

Irritability or ulceration of the large intestine is sometimes indicated in a very marked manner. For the diagnosis of diseases of these organs the faradic current, on account of its superior mechanical effects, is preferable to the galvanic.

Formerly the first type was the more prevalent; latterly the second type is much the more frequent, especially among the higher classes. This change in type calls for a corresponding change in treatment. The depletion and abstinence and powerful purgatives which proved so efficacious in the "indigestion" and "biliousness" of former days, only aggravates much of the nervous dyspepsia and constipation of the present generation. Experience sustains the assertion that the majority of patients in the higher order of society who suffer from dyspepsia, constipation, etc., are benefited more by nourishing food than by starvation—more by tonics than by purgatives.*

General Principles of Treatment.—Electrical treatment is serviceable in the diseases of the organs of digestion in two ways: *First*, by the mechanical influence of the current on the tissues of the organs; *Secondly*, by its tonic influence on the spinal cord, sympathetic, and entire nervous system. In the first type the former influence, in the second type the latter is indicated. The tonic influence on the nervous system may be obtained by galvanization of the spine, brain, sympathetic and pneumogastric, and by general electrization. The mechanical influence on the tissues of the viscera may be obtained by general or localized faradization.

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* These remarks will apply with nearly equal force to some other diseases besides those of the organs of digestion. We have been led to make them in this chapter because the diseases here spoken of are so exceedingly frequent, and because the distinction between the two types and the fact of the change of type is not yet universally understood. We are continually consulted by patients afflicted with the symptoms above named, who have been not a little injured by excessive use of purgatives and laxatives, to whom it has never been suggested that the spinal cord or some other portion of the nervous system might be at fault.

Dr. John Brown, in the charming essay, "My Father's Memoir," before quoted, thus remarks: "He was during life subject to sudden headaches, affecting his memory and eye-sight, and even his speech; these attacks were, according to the thoughtless phrase of the day, called bilious—that is, he was sick and was relieved by a blue-pill and smart medicine. Their true seat was in the brain; the liver suffered because the brain was ill and sent no nervous energy to it, or poisoned what it did send."

A fundamental fact of great importance in the treatment of disorders of the digestive tract is this, that *for direct applications to the abdominal viscera,—stomach, spleen, liver, intestines, and uterus,—the faradic current is far preferable to the galvanic.* The reasons for this are twofold:—

1. The faradic current acts more vigorously on the contractile fibre-cells of the organs than the galvanic, and therefore produces more powerful *mechanical* effects, with *passive exercise* of all the deep tissues. (See p. 155.)

2. These parts are so situated anatomically, and are so liberally supplied with warm saline solutions, that they conduct the faradic current under all conditions with perfect ease. (See p. 89.)

In the brain and spinal cord and sympathetic these conditions are reversed, and they are best treated by the galvanic current. (See p. 153.)

Localized Electrization of the Abdominal Viscera.—The stomach and liver may be indirectly galvanized through the pneumogastric in the neck; the stomach, liver, spleen, kidneys, and intestines may be directly faradized by applying large electrodes with very fine pressure over the back and abdomen, so as to pass the current directly through the organ that we wish to affect. Except in cases of disease, these organs will bear with very strong currents without severe discomfort. Either stable or labile applications may be used, without regard to the direction of the current, from three to five minutes, or even longer.

Dyspepsia, accompanied by a voracious appetite and a constant burning in the stomach, dependent on vascular irritation of its mucous membrane—Approximate recovery under treatment by general faradization.

CASE 108.—The case of Mr. S., aged 31, presented symptoms of the old-fashioned variety of indigestion. His appearance did not indicate any special or annoying disease.

A year previously he began to experience an uneasy feeling in the epigastric region after eating a hearty meal. This symptom gradually became more aggravated, until it was a source of serious annoyance.

He had been advised to limit himself to a spare diet, and had attempted to regulate the quantity and quality of his food. In this he failed on account of another symptom, which before had escaped his observation. We refer to bulimia — in other words, a voracious appetite, which refused to be controlled. The enormous amount of food which he devoured at every meal was but partially digested. A considerable portion was occasionally vomited. When his meals were withheld a short time, he experienced an indescribable "sinking" at the stomach, impelling him to seize voraciously on articles of food. He complained especially of a constant sensation of heat, or a burning pain in the epigastrium, which was aggravated by the ingestion of food. We ascribed this symptom to an excessive vascular irritation of the mucous membrane of the stomach.

An unequal circulation was manifested by cold extremities during the day, and hot feet at night.

Derangement of the hepatic function was evident by the light clay-colored stools, while the urine was invariably almost colorless. The patient was accustomed to the habitual use of alcoholic stimulants, but never to the point of intoxication. He had used strong coffee and tea to excess, but had for some months abstained from them altogether. The faradic current was acutely felt over the stomach. Over the body generally, however, he bore a current of more than ordinary intensity. Three applications given in the course of a week appreciably lessened the irritation of the diseased organ. This effect was evinced by a decrease in the burning sensation, which was mentioned as a disagreeable and marked symptom. The vomiting was effectually controlled after two weeks of treatment. Twenty applications administered during a period of two months resulted in an approximate cure.

The voracious appetite was in a great measure subdued, and it was only after some indiscretion in diet that any of the old local symptoms returned sufficient to annoy the patient.

NERVOUS DYSPEPSIA (DYSPEPSIE ASTHENIQUE).

Under this somewhat vague term are included a large and diverse variety of symptoms that depend on some irritation or morbid condition of the nerves that supply the organs of digestion. This morbid condition may probably be peripheral as well as central. Much more frequently than is supposed, the symptoms are due to spinal irritation or to some diseased condition of the central nervous system. That the oftentimes meaningless terms, dyspepsia and indigestion, like "biliousness," are exceedingly abused by the profession as well as by the laity, there can be no question ; but this abuse finds not a little justification in the fact that the distressing sensations and conditions which these terms are designed to express are exceedingly frequent. Our object here is not to enter into any detailed description of the symptoms and cause of this so very familiar malady, but merely to show its relation to some of the other neuroses, and to indicate the *rationale* and the results of its treatment by electrization.

Among the leading and distinctive symptoms of nervous dyspepsia are distress and uneasiness in the stomach during or after eating, or when the stomach is empty ; pain or spasms in the stomach, from emotional causes ; sick-headache ; constipation, or sometimes diarrhœa ; deficiency of thirst, mental depression, and general debility. Any one of these symptoms may arise from some inflammatory condition of the stomach or other portions of the digestive tract ; but all of them together, when found in a nervous constitution, point to a nervous origin.

It may be remarked concerning this form of dyspepsia :—

1. It is most frequently found in nervous communities and among nervous individuals. In barbarous and semi-civilized lands, indigestions—caused by some phase of inflammation of the stomach, resulting from gastritis caused by excesses in eating and drinking, from prolonged abstinence, from exposures and privations incident to their unsettled condition—are indeed not uncommon ; but the symptoms of such indigestions are not only different from the dyspepsia of nervous communities and nervous organizations, but they are also less distressing and less permanent. Comparing the different civilized lands, we find that dyspepsia is more frequent among those who use the brain most exclusively and most intensely, and who, as a logical consequence, are most nervous. Among the Germans, the most phlegmatic of civilized people, the term dyspepsia is almost unknown, because the disease itself is comparatively rare. In France the term is much more frequently used and is better understood, and among women especially is not unfrequent. In England dyspepsia is probably more common than in any other country except the United States. But it is in the United States that dyspepsia finds its chosen home—where

as has been stated, the nervous diathesis is most strongly marked. It is here found among all orders of society, though chiefly, of course, among the intellectual and cultivated. It may be said as a rule, that in proportion as men become nervous, in that proportion do they become liable to dyspepsia. It is probably safe to say that nine out of ten of the cases of dyspepsia among the better classes of America are of the nervous variety.

2. It alternates with other well-recognized nervous symptoms, and is frequently developed by metastasis. The nervous connection of the stomach and the other organs of digestion is so direct and so complex, that any disorder of the brain, of the spinal cord, or of any of the peripheral nerves, may at once affect the digestive process and bring on the varied symptoms of dyspepsia. This transference of pain, or distress, or uneasiness, from different parts of the body to the stomach may be instantaneous. Thus, pain in the head may be telegraphed to the epigastric region with the speed of nervous force, and *vice versâ*. The interdependence of the genital and the digestive apparatus is so direct, that morbid sensations may be transferred almost instantly from one to the other. Exhaustion of the brain from over-study, as many literary workers will attest, may be felt in the stomach, while the head suffers not at all. Just so unpleasant mental or moral impressions seem to affect the stomach and brain almost simultaneously, so as to destroy the appetite in the midst of a meal. The important fact to be considered is that *nervous dyspepsia, so far from being a merely local disease of the stomach, is simply one of many manifestations of the nervous diathesis, and is developed by whatever causes tend to debilitate the nervous system, and may variously alternate with almost any conceivable phase of nervous disease in any part of the body.* Usually, however, the concentration of the nervous diathesis upon the stomach, giving rise to the symptoms which we call dyspepsia, is comparatively slow, and may only be developed after the patient has been a nervous sufferer for many months and years. Thus long-standing weakness of the genital organs, in male or female, frequently assumes the form of dyspepsia, or rather runs into it, leaving the genital organs perhaps comparatively free from irritation. This law in re-

gard to the metastasis of nervous affections works both ways ; dyspepsia itself may pass into some other and perhaps more serious affection of the nervous system. Metastasis of disease of the stomach to the spinal cord or the brain, or some portion of the periphery of the nervous system, is more markedly observed than the metastasis of disease from these other parts to the stomach. Close observation will show that of those who in mature or advanced life are prostrated by disease of the brain or cord, or are made wretched by constitutional neuralgia, a large number were at some period of their lives dyspeptics. Neglect of this symptom, continued perhaps for years, and combined, it may be, with persistent abuse of the nervous system by over-work or over-worry, or by over-indulgence of the passions, has had the effect to drive the disease from the stomach, but at the same time to cause it to take its seat and intrench itself in some more important stronghold, as the brain or the spinal cord.

The organs most abused in childhood, before puberty, are the digestive ; in early manhood the genitals ; in maturity and old age the brain ; correspondingly we find that childhood is disposed to derangements of the digestive system ; early manhood to disorders of the genitals, and maturity and old age to organic affections of the central nervous system. Thus, paraplegia may be the terminal symptom of the nervous diathesis which in early life manifested itself by dyspepsia.

3. Nervous dyspepsia is relieved by the methods of treatment which are found most successful in other functional nervous disorders. The indigestions of former days and from which our fathers suffered were frequently, perhaps usually, symptomatic of chronic gastritis and hepatic engorgement, and were therefore relieved by purgatives and dieting, by blue-pill and bleeding. But the nervous dyspepsia of our times, of the modern constitution, is a very different affection, and is usually aggravated by purgatives and depletion, and best relieved by *tonics.* The ordinary bitters are not sufficient ; the dyspeptic needs tonics that not only temporarily sharpen the appetite, but which strengthen and fortify the nervous system, which remove the debility of which the dyspepsia is simply one of the symptoms.

Electro-diagnosis.—In nervous dyspepsia there is frequently a peculiar and very unpleasant tenderness in the epigastric region, so that only a very mild current can be borne. In some cases a thrill, with a sinking sensation, is felt when the electrode with a strong current is passed down the spine; in other cases the application of a strong current at the cilio-spinal centre, or on the crown of the head, causes a feeling of nausea. The spinal irritation, on which nervous dyspepsia so frequently depends, is indicated by tenderness of the dorsal vertebræ on pressure or on application of the current.

Treatment.—We know of no treatment so sure to relieve the leading and concomitant phenomena of dyspepsia as general faradization. In connection with this we sometimes use galvanization of the sympathetic, the pneumogastric, and spine. General electrization relieves nervous dyspepsia, not so much by the virtue of its influence on the stomach—although it directly affects the stomach—as by its influence on the nervous condition of which the dyspepsia is a symptom.

The number of our cases in which dyspepsia was the only symptom was comparatively small; the number in which it was a prominent accompanying symptom was quite large. Most of the cases of hysteria, nervous exhaustion, and hypochondriasis, and very many of the cases of neuralgia and paralysis, were more or less complicated with dyspeptic symptoms. Relief of dyspepsia is one of the earlier signs of improvement under general electrization, even when treating cases in which it is merely an incidental condition.

Prognosis.—For the temporary or permanent relief of nervous dyspepsia, the prognosis under the treatment above indicated is exceedingly favorable, and the *results obtained by general faradization alone are some of the most remarkable in therapeutics.* Cases of nervous dyspepsia, with their manifold complications, are on the whole the best tests that can be offered for this method of treatment. Not only are the purely dyspeptic symptoms relieved, but there is great improvement in sleep, and in strength of muscle and brain, and in some cases very marked increase in weight. Relapses are not unfrequent in this disease, especially under bad hygienic influences; but are, if anything, less frequent after general electrization than after many other methods of treatment. *It is in this disease that the general improvement in nutrition and consequent increase in weight that result from general faradization are most frequently observed.*

The exceptional cases that do not yield at all to general electrization are usually in the aged, or are of very long standing, or are complicated with other incurable conditions.

Of the 75 cases that we have treated in which nervous dyspepsia was a prominent symptom—30 recovered; 14 approximately recovered; 18 were greatly benefited; 6 slightly benefited; 3 were not benefited; and in 4 cases the results are unknown.

Dyspepsia, chronic diarrhœa, and great susceptibility to diseases of mucous membranes—Unusual susceptibility to electrization—Important improvement under general electrization.

CASE 109.—Mr. U——, aged 40, consulted us Nov. 12, 1868. All his life the patient had been feeble and had suffered for years from dyspepsia. His system was morbidly impressible to injurious influences. He was somewhat anæmic. General faradization was tried cautiously, and also localized faradization through the bowels by means of a rectal electrode.

The first application, though gentle, disturbed his sleep, increased his nervousness, and aggravated all his symptoms. It was found to be necessary to use peculiar caution in making even localized applications.

On several occasions we had reason to know from the sensations of the patient that the treatment, though unusually short and mild, was yet too long or too severe for his constitution. This susceptibility was the more striking from the fact that the patient retained considerable vigor, and was able to walk a reasonable distance and to engage in active mental employment.

As soon as we became familiar with the peculiarities of his constitution the patient began to derive positive benefit, and no longer experienced any of the unpleasant reactive effects.

The patient left us after a month's treatment, greatly improved.

Dyspepsia in the aged, like all other marked conditions of the decline of life, is much less disposed to yield to electrization than the same symptoms in the young or middle-aged.

Life-long dyspepsia, with extraordinary hyperæsthesia and transference of sensation—No improvement.

CASE 110.—Rev. Mr. S——, aged 61, came to us May 29, 1869, giving a peculiar history. Many years before he had been compelled to abandon preaching, on account of aggravated dyspepsia, complicated with distressing symptoms in the head. His stomach was so sensitive that, to use his own language, "it took the place of the auditory nerve," and every audible or perceptible sound seemed to strike against the epigastrium. At the time he consulted us he for some time had been acting as editor of two prominent magazines, and over-toil had superinduced an exacerbation of his dyspeptic symptoms.

Electric examination gave no special indications beyond sensitiveness in the epigastrium. General faradization, pretty faithfully tried, availed to give temporary but not permanent results. A brief application to the head caused, the night and day following, very disagreeable sensations, similar, as the patient described them, to those of delirium tremens, or those sometimes experienced from a dose of hasheesh. Galvanization, either general or local, was not tried.

Dyspepsia, with nervousness—Improvement under general faradization.

CASE 111.—Mr. S—— came to us in Nov., 1866, complaining of headache, ringing in the head, vertigo, acidity of the stomach, with distress after eating—in short, of all the usual symptoms of dyspepsia. His temperament was exceedingly nervous.

We told him that the treatment would be protracted, and advised him to receive an application once or twice a week at least. For the first week or two there was no very marked improvement, although he said he always felt very much exhilarated after each application. After four or five sittings, the change for the better was very decided. Not only were his dyspeptic symptoms relieved, but his general nervousness was diminished.

His appetite was less capricious and exacting. Before using electricity he had felt compelled to take food very often; he was now content with three meals daily. When we last saw him he was a calmer as well as sturdier man.

Dyspepsia of many years' standing—Great improvement under general faradization, and increase in weight of 30 pounds.

CASE 112.—Mr. T——, a bookseller, aged 31, stated that for a number of years he had suffered from chronic dyspepsia, which had rendered his life miserable. He had lost much in flesh. Although 5 ft. 8 ins. in height, his weight was but about one hundred pounds. He complained of regurgitations from the stomach of an intensely sour liquid, and on rising in the morning he was often troubled with pyrosis. Tympanitis was a frequent symptom, and oftentimes the accumulation of gas within the stomach embarrassed the respiration and disturbed the action of the heart. Treatment was commenced about the middle of October, 1866, and continued for four weeks, general faradization being applied three times each week. The daily regurgitations, the tympanitis and pyrosis, gradually ceased to annoy him; and after the tenth application, he informed us that during the month he had increased in weight some fifteen pounds.

About the beginning of January, 1867, he called upon us, stating that his health was excellent, and that his total increase in weight, since he first commenced treatment by electricity, was some thirty pounds. He said that he did not feel that his digestive organs were as strong as they had been before he was attacked with dyspepsia, but they had ceased to give him any considerable annoyance.

Nervous dyspepsia, associated with periodical attacks of headache and vomiting —Approximate recovery and rapid increase in weight follow general faradization.

CASE 113.—A young man consulted us in the Fall of 1866 for a persistent form of nervous dyspepsia.

He was of a weak nervous organization, and presented a remarkably anæmic and emaciated appearance. Every month or six weeks he was prostrated by a severe attack of headache and vomiting, from the effects of which he would not recover for several days. In administering a general application of the faradic current, it was found that the liver was relatively the most sensitive to its influence. So exhausting was the sensation produced by the electricity in this organ, that very decided symptoms of faintness followed. He soon rallied from its effects, and when he visited us two days subsequently, he expressed himself as having experienced very marked and grateful relief. At each sitting he was able to bear a more intense current over the digestive organs and body generally. The beneficial effects of the applications were soon manifest by a more natural and lively appetite, relief of constipation, by greatly increased vigor of mind and body, and by the non-recurrence of his usual paroxysm of headache and vomiting. The first application was given October 24, and the fifteenth and last in the early part of December. During the treatment the weight of this patient increased from 106 to 115.

A large number of cases of nervous dyspepsia will be found under hysteria, hypochondriasis, anæmia, and neuralgia and paralysis.

Nervous Constipation, Chronic Diarrhœa, and Jaundice.—Constipation, associated with and constituting a part of nervous dyspepsia, is, like dyspepsia, disposed to yield rapidly, and often permanently, to general electrization, even when no special attention is given to the lower part of the back or the abdomen. This is the form of constipation that is most prevalent. *Next to insomnia, it is the symptom first to yield*, even though there may be subsequent relapse. Very many of the cases related under dyspepsia, hypochondriasis, hysteria, and nervous exhaustion, were to a greater or less extent troubled with constipation, even when this symptom was not specified; and in the majority of cases there was important relief.

The relief is sometimes merely temporary; relapses are most likely to occur in those cases that are of a hereditary, or at least life-long character.

It not unfrequently happens that a strong application is followed the next, or even the same day by a freer alvine discharge than usual. Constipation, much more frequently than is supposed, depends on an irritable, exhausted, or congested condition of the spinal cord. That myelitis and the more serious lesions of the spinal cord are accompanied by a deranged condition of the bowels, either constipation or diarrhœa, is fully recognized; it is not, however, so well understood that spinal irritation, even in its milder degrees, may have constipation for one of its symptoms, and that this symptom will disappear with the removal of the cause, by treatment directed to the spine. For those cases that result from incurable disease of the brain or spinal cord, only temporary relief can be obtained. In such cases relapse usually occurs as soon as the treatment is discontinued.

Electrization may therefore be said to relieve constipation in several different ways:—

1. By its general tonic effects on the system at large, on the same principle that it relieves nervous dyspepsia.

2. By its tonic effects on the central nervous system, and especially on the spinal cord. On account of the fact that very many cases of constipation depend on a morbid condition of the cord, special attention should be given to the spine, whatever may be the method of electrization employed.

3. By its direct effects on the organs of digestion. The mechanical action of the faradic current especially gives tone to the stomach, liver, and intestines, markedly increases the hepatic and intestinal secretions, and aids the peristaltic action of the intestines.

Prognosis.—Constipation is so frequently associated with other symptoms, that the majority of cases are registered under other diseases, as dyspepsia, hysteria, etc.

Of 14 cases that we have classified under this disease, 6 recovered, 3 approximately recovered, 3 were decidedly benefited, 2 were slightly benefited, and in one case the result is unknown.

(Cases of constipation will be found under dyspepsia, neurasthenia, hysteria, and paralysis.)

In *regurgitation* the prognosis appears to be very encouraging. In *jaundice* the results of our limited experience have been more favorable than the reverse. In *chronic diarrhœa* we have succeeded in three striking instances.

The treatment of all of these conditions is worthy of far more attention than it has thus far received from electro-therapeutists. In the hands of the laity many of these symptoms have been treated by faradization, with various results, for many years.

Habitual constipation for fifteen years—No permanent benefit from medication—Rapid improvement under general faradization—Relapse.

CASE 114.—Mr. N., aged 30, a printer employed in the office of the *N. Y. Times*, was sent to us by Dr. St. John Roosa. For fifteen years he had suffered from constipation. So persistent were the symptoms, that neither well-directed medication nor such hygienic measures as he could command were of any avail.

The appetite was good, and the sleep moderately sound and refreshing. The patient complained of a sense of weight or oppression in the abdomen, of flatulence, and occasionally of a slight feeling of nausea.

The evacuations often came away in knotty lumps, after much straining and an unpleasant distention of the anus. As a consequence of this torpor or want of susceptibility of the intestines, his health had become considerably impaired. He complained of a general feeling of malaise and a disinclination to engage in any active effort. Above all, however, he suffered continually from most painful mental depression. The monotony and confinement of his occupation, together with the unnatural method of life of working at night and sleeping during the day, doubtless served to aggravate the character of his disorder. He received only three applications of the faradic current, which resulted in an extraordinary improvement in his general symptoms. After the first séance the bowels moved freely, and continued to do so every day while he visited us He was completely relieved of his mental and physical depression, and in every respect was more vigorous than for many years before.

The bowels continued regular for several months, when the old symptoms gradually returned. The patient again applied to us for treatment, and was relieved as effectually as before. We have heard nothing more concerning him, and are hopeful that he was more permanently benefited.

Life-long constipation—Apparent recovery under general faradization.

CASE 115.—Another case sent by Dr. Roosa presented symptoms similar to the first. So long as the patient could remember, his bowels had uniformly acted in a sluggish manner. He seldom had a passage oftener than once in two days, and frequently a week would intervene from one evacuation to the next. As in the former case, the stools were hard and scanty, but the general health was not impaired to the same extent. As a rule, his spirits were moderately buoyant, the appetite good, and the sleep refreshing. He complained but little of any unpleasant symptoms, with the exception of an unusual dryness of the fauces and a disagreeable taste in the mouth.

The first general application of the faradic current was given October 24th, 1867, and resulted during the day in an evacuation every way more easy and natural than usual. After the fifth séance his stools became quite liquid and frequent. This condition was, however, remedied by omitting the applications for a few days.

He visited us subsequently but two or three times, when he discontinued treatment, having, as far as we could judge, experienced perfect relief.

Habitual constipation—Numbness of right arm—Improvement under general faradization—Relapses.

CASE 116.—A well-known dentist of this city complained that his bowels were in a very torpid condition, and that for the space of a year he rarely if ever had a free and satisfactory movement without the aid of laxatives or injections.

He was annoyed also by a considerable numbness of the right arm, and this condition was invariably aggravated whenever the constipation was more persistent than usual. After being treated most thoroughly, and with a current of great power on three different occasions (during this time taking neither laxatives nor injections), a free and natural movement of the bowels followed. The anæsthesia of the arm was somewhat alleviated by the first and second application, but was almost entirely relieved after the free evacuation. The constipation in the case of this gentleman was by no means permanently cured.

The old condition returned in a few weeks, but was less aggravating in character.

Two applications relieved the patient as before. From time to time he finds the electric treatment advantageous, and although the relief afforded is not complete and permanent, yet in comparison with his former condition he suffers but little annoyance.

In some cases of very obstinate constipation it is of advantage to localize the current by *internal applications*. This may be accomplished by means of a rectal electrode (Figs. 72 and 73).

This may either be non-insulated, or insulated up to a point near the tip.

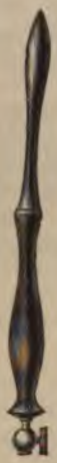

FIG. 72.

Rectal Electrode non-insulated.

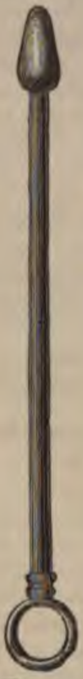

FIG. 73.

Rectal Electrode insulated.

A very powerful current may be borne in the rectum without discomfort. The other pole may be applied at different points over the abdomen.

Ileus (*Invagination*).—Althaus reports two cases where powerful faradization availed to cure constipation when the ordinary remedies had been tried in vain. The negative pole was applied to the spine, and the positive passed over the abdomen in the region of the large intestine. In three minutes a very abundant evacuation appeared.

The second case was severe, but not as long standing as the other. The patient passed much blood at stool, and was fast becoming exhausted. The same application brought relief, though not so speedily as in the preceding case.

Dr. Clemens, of Frankfort, states that he has successfully treated invagination by first administering one or two tablespoonfuls of metallic mercury, which settled down to the seat of the invagination. The negative electrode was applied over the supposed seat of the disease, and the positive in the rectum. Voltaic alternatives were used.*

Chronic diarrhœa of six months' standing, associated with general neuralgia —Marked tenderness over the transverse colon—Treated by general faradization, with special reference to the tender spot—Recovery in three weeks.

CASE 117.—A lady, aged 35, applied for treatment because of a general neuralgia, from which at times she suffered excessively. The faradic current

* Althaus, op. cit., p. 603.

was applied over the whole body, and produced no discomfort, excepting when it was sent through a certain part of the intestinal tract.

This tender spot was located on the right side, directly over the transverse colon. Over no other portion of the abdomen was she at all sensitive to the electricity, but at this point a very moderate current produced a disagreeable, sharp, burning pain, similar to that caused by making the application to a raw surface. Upon inquiry, the patient stated that for six months she had been annoyed by a diarrhœa, which persisted in spite of persevering and judicious medication. She was obliged to exercise the utmost caution in her diet, for the least indiscretion in eating was certain to aggravate her disorder.

We now directed the applications more especially to this *tender* spot, and soon observed some amelioration of her diarrhœal symptoms. The stools assumed a firmer consistency and a more healthy color, and in proportion as she improved in these respects the tender spot became less sensitive to the influences of the electric current. Eight applications, extended over a period of three weeks, resulted in complete recovery.

Diarrhœa of several months' standing in a lad of 12 years, caused by exposure to cold—Recovery under ten general faradizations—Increase in weight.

CASE 118.—J. W., aged twelve years, was annoyed by an excessive looseness of the bowels, which had persisted for several months in spite of every form of medication that had been tried. He was of a delicate constitution, but until this attack of diarrhœa he had always enjoyed a good degree of health. His mother attributed his disorder to exposure during a cold, damp day, at a time when his system was a little below par from too close confinement in the school-room.

A moderate amount of food caused no discomfort, but his power of assimilation was considerably impaired, as shown by the great quantity of aliment that passed his bowels daily. Ordinarily he had five or six evacuations during the twenty-four hours; but if he indulged to any extent in athletic exercises the symptoms became more urgent.

On one occasion, after indulging for an hour in a game of ball, he was annoyed during the night by nearly a dozen evacuations, which were attended with considerable pain. As might be inferred, this constant drain upon his system had still further decreased his limited stock of vitality, and he had lost within three months some twelve pounds in weight.

The first four applications worked no important change in his general condition.

After the fifth visit there were manifest signs of improvement. During the twenty-four hours following he was compelled to evacuate his bowels but three times, instead of five or six. The improvement continued after each subsequent application, until the number of passages was reduced to one daily. The fæces were of a firm consistency and unmixed with undigested food. The evacuations caused no suffering, and, more than all, he had gained nearly six pounds in weight. He could indulge in all the ordinary sports of his school-fellows without any evil consequences following.

The patient was under treatment nearly a month, and the number of applications administered was ten.

Chronic diarrhœa with excessive pains in back and abdomen—Great debility—Very great improvement from general electrization.

CASE 119.—Miss I., a lady 30 years of age, was referred to us by Prof. J. T. Metcalfe, Oct. 21, 1869, to be treated for chronic diarrhœa of four years' standing, alternated with some anæmia and muscular weakness. The discharges, sometimes several daily, were frequently followed by severe pain. Debility was so excessive that she was over-fatigued by a walk of a quarter of a mile. Her appetite was capricious and digestion imperfect, and the condition of her bowels made necessary constant caution. The patient referred her difficulties to exhaustion caused by attendance on an invalid sister.

Electric examination revealed a marked tenderness over the transverse colon, which varied at different times.

The patient was treated by general faradization, at first cautiously, but soon as she proved able to bear it, with greater freedom, by intervals, for three months, the applications being made every other day. Improvement began early, and its march was continuous and mostly uniform. The discharges were gradually reduced in frequency, with relief of the accompanying pain, though

Gastralgia of six months' standing, with jaundice—Rapid and permanent recovery under general and localized faradization.

CASE 120.—Miss W., aged 47, had for six months suffered from most violent attacks of gastralgia, accompanied by yellowness of the skin and conjunctiva that had become a fixed condition. All her mature life she had been a sufferer from dyspepsia, and more recently had been annoyed by chronic diarrhœa. A residence in the South the winter previous seemed to have still further deranged the digestive organs, and when she returned North in June, 1869, she was suffering attacks of gastralgia of the most violent and excruciating form, one, two, and three times weekly. These repeated attacks had reduced her naturally feeble strength, and perceptibly impaired nutrition. Her stomach was so excessively sensitive that only the lightest and most delicate articles could be borne. Even very moderate quantities of meat or bread, slowly eaten, would bring on an attack. Withal there was painful restlessness, insomnia, and slight tingling and numbness in the hands.

Medication of various kinds had failed to afford any positive relief, and when we saw the patient, Jan. 1, 1870, she had been for three weeks bed-ridden, and was apparently growing weaker every day.

Electric examination revealed a very unusual anæsthesia of the liver; the whole power of Kidder's machine, when localized through the right hypochondrial region, was not painful, and a current of moderate strength was scarcely felt. There was, moreover, a general anæsthetic condition of the system, since, though a very nervous patient, she could even then bear more than a majority of persons of health. The stools were of a clay color.

The treatment employed was general and localized faradization, sometimes alternately at each application. As the patient was too weak to sit up, the applications were given in bed, but were not made with thoroughness, being chiefly directed to the trunk, and especially to the liver, solar plexus, spine, and cervical sympathetic.

The first application, which was given in the evening, was followed by a better night's rest than usual; but the day following the patient was annoyed by a peculiar sensation through all the nerve-tracks of the extremities—to use her own expression, she "*felt the electricity all through her.*" (This phenomenon is not infrequently observed in nervous patients, after powerful applications.) Two days subsequent to the application a slight attack of gastralgia came on, which was in time relieved. *It was her last attack.* She was allowed an interval of rest for five days, when the applications were renewed for two successive evenings, and each time with an increased strength of current, and so on for four weeks. By February 1 the patient was able to sit up a good part of the day. The symptom first to yield was *insomnia*, next the attacks of *gastralgia*, then the *indigestion and gastric irritability, and finally the skin and conjunctiva resumed their natural color.*

By Feb. 15th, the patient could eat without annoyance nearly all the ordinary articles, and was able to resume her daily duties. The bowels, which during her illness had been constipated, became loose, with two discharges daily, and the stools were of a natural color.

The case presented some peculiarities, which were not, however, unprecedented. One was her ability to bear such powerful applications in all parts of the body, even over the irritable stomach; another feature was the indescribable sensitiveness through the extremities for a day or two following the applications. At the date of writing the patient continues well. The case is remarkable not so much for the permanency of the recovery as for its rapidity.

Jaundice—No improvement after persistent use of general and localized faradization.

CASE 121.—Mr. A., aged 48, consulted us in May, 1867, for the relief of jaundice, that had come on gradually and without any other symptom except some heaviness and depression. The patient was of a strong frame, and his health had usually been excellent.

There was no indication of enlargement or other organic disease of the liver.

Treatment by general and localized faradization was perseveringly and variously employed, without any result. The patient subsequently recovered under internal medication.

We have records of 6 cases of jaundice; of these 5 recovered, and 1 was not benefited.

REGURGITATION AND VOMITING.

For those cases of vomiting that are of an obviously nervous character, galvanization of the sympathetic and pneumogastric, or strong faradization through the stomach, is sometimes of important service. Successful results have been obtained by Pepper and Bricheteau. The latter treated with success three cases of vomiting of pregnancy. His method of application was to place the electrodes on the epigastrium at the commencement, middle, and close of the meal.

It is well in such cases, especially if they are obstinate, to try a variety of methods: galvanization of the sympathetic and vagus, and of the spine, faradization through the stomach with a strong stable current, and general electrization.

FLATULENCE.

Flatulence is a symptom of disorder of the digestive organs that very readily yields to electrical treatment. It demands the same treatment as dyspepsia and constipation. Those very frequent cases that depend on spinal irritation and congestion, and on hysteria, need central galvanization or general faradization; cases that depend on an attack of acute indigestion may be advantageously treated by internal applications, one pole being applied to the rectum by the rectal electrode, and the other to the spine or abdomen.

Flatulence was a symptom in very many of our cases of dyspepsia, hysteria, and spinal irritation, and almost uniformly it temporarily or permanently yielded.

SEA-SICKNESS.

In October, 1869, Mr. Le Coniat, a French surgeon, presented a method of treating sea-sickness, before the New York Medical Journal Association. Subsequently a detailed account of the method was published by Dr. Dwinelle,* who had experienced the good effects of the treatment on his own person in a passage across the Atlantic.

His method was to first apply a quantity of solution of atropine —one grain to the ounce—to the epigastrium, then to apply a flat disk, connected with a faradic apparatus, over the pyloric extremity of the stomach, while a moistened sponge connected with the positive pole was passed over the surface, from the cardiac to the pyloric orifice.

Vigorous contractions of the muscles appeared during the applications, which were followed by agreeable repose.

Le Coniat claims to cure by this method 90 per cent. of his cases.

The statements made by Coniat and Dwinelle lose much of their scientific as well as of their practical value, from the fact that the atropine was combined with the faradization.

There is little doubt that the passage of the electric currents through the body facilitates the absorption of liquids; placed beneath the electrodes; moreover, it is well known that the skin is capable of absorbing liquids without the aid of the electric currents. The quenching of thirst by bathing is a very familiar illustration.

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* New York Medical Journal, 1869, p. 390.

Then again, atropine is a remedy so powerful that $\frac{1}{100}$ or even $\frac{1}{200}$ of a grain is sufficient to powerfully affect the nervous system, when administered hypodermically. Furthermore, it is a remedy for sea-sickness and sick-headache, as has been shown by experiments of ourselves and others who have employed hypodermic injections of this remedy combined with morphine. A dose containing $\frac{1}{100}$ of a grain of atropine and $\frac{1}{8}$ of a grain of morphine is sufficient in certain cases to relieve the nausea and vomiting, and produce sleep—the same effects that are produced by the operation of Le Coniat.

From all these considerations, taken in connection with the further consideration that sea-sickness is probably not a disease of the stomach alone, but of the central nervous system, of which the nausea and vomiting are frequent but by no means necessary symptoms, we are strongly inclined to the belief that the results obtained by Le Coniat's procedure could have been obtained with much less difficulty by hypodermic injections of atropine.

CHAPTER XXIX.

DISEASES OF WOMEN.

THE diseases of female sexual organs for which electrization has been proved to be of service are chiefly those of a functional character, as *amenorrhœa*, *dysmenorrhœa*, *menorrhagia*, although some important results have been claimed by a few in *chronic inflammation*, *enlargements*, and in *displacements of the uterus.*

AMENORRHŒA, DYSMENORRHŒA, MENORRHAGIA, AND LEUCORRHŒA.

These symptoms of disease are of course most amenable to electrization when they are not dependent on any severe or incurable pathological condition, but are merely indications of functional derangement. The inconsistency and uncertainty of the results of the treatment of these symptoms by electricity is entirely explicable to all who are conversant with uterine pathology; cases that are indiscriminately treated by any method must, of course, result in a manner at once inconsistent, and frequently very disappointing.

Furthermore it should be considered that, as the ablest gynæcologists are forced to admit, the diagnosis "functional," as applied to diseases of the female sexual organs especially, simply means that there are no recognizable local pathological lesions that will account for the symptoms. Of necessity, therefore, many of the cases that are classed under this head must be and are of a widely diverse character. To expect uniform results in such cases, or to be disappointed by failure even in symptoms that seem particularly adapted for electrical treatment, is in the highest degree unreasonable.

While these remarks are true of all the so-called functional diseases of all parts of the body, they apply with special force to diseases of women.

Treatment of Diseases of the Uterus.—Local, central, and general treatment may be employed. The local treatment may be either external or internal.

External Method.—Externally, the uterus and its appendages may be electrized by placing one pole with firm pressure over the hypogastric region, and the other over the lumbar region of the spine.

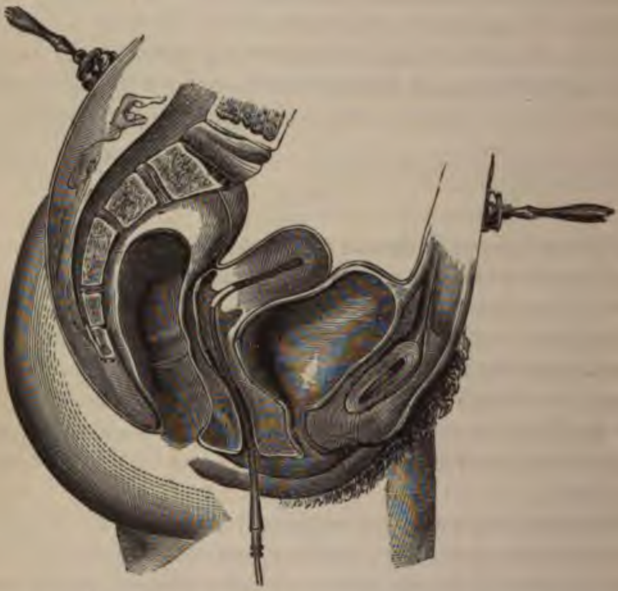


FIG. 74.—FARADIZATION OF THE UTERUS.—One of the poles is connected with a bifurcated electrode, one branch of which is placed on the lumbar, and the other on the hypogastric region. The other pole is applied in the cervix (or at the os) by an insulated uterine electrode. (The normal position of the uterus is after Wieland and Dubrisay.)

This method is sometimes as effective as internal applications, and, in virgins at least, should always be tried at first. In this method benefit is derived partly from the effect of the current on the lower part of the spinal cord and the abdominal ganglia of the sympathetic.

Internal Method.—Electric currents may be localized in the female organs of generation in a variety of ways. One pole may be applied to the os by means of an insulated electrode with a metallic bulb (Fig. 76), while the other, with a broad electrode, is applied to the back, or on the hypogastric region, or over one of the ovaries. Instead of a metallic bulb the uterine electrode may be composed of branches to clasp the cervix. A much stronger current can be borne at the cervix than would be supposed.

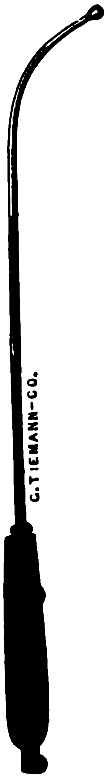


FIG. 75.
Intra-Uterine Electrode.

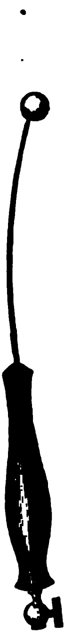


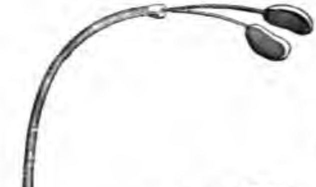
FIG. 76.
Uterine Electrode.

A method of faradizing the uterus is represented in the accompanying cut (Fig. 74).

For intra-uterine faradization we have devised an *intra-uterine electrode* which is represented in the cut. The basis of the instrument is similar to Sims' sound. This is insulated with varnish up to within three inches of the extremity; the handle is of hard rubber, and is provided with a hole and screw for fastening the connecting wire of the apparatus, and a button connected with a spring by means of which the connection of the current can be made or broken at pleasure. The manifest advantages of the interrupter, which is similar to that of the universal electrode holder (Fig. 35, p. 138), is that it dispenses with the necessity of waiting until the instrument is in situ before connecting it with the apparatus, and that it makes it convenient to give rapid interruptions and to instantaneously suspend the treatment when required.

When properly curved, this electrode may be used for the larynx.

Fig. 77 represents the ***double uterine electrode*** of Duchenne.* This is composed of two plates, connected with flexible wires, which pass through a sound, but are insulated from each other. On pushing in slightly the wires at the point where the connection with the apparatus is made, the poles separate as in Fig. 77. On again drawing them in, they close as in Fig. 78. The instrument, which is the same in principle as the *double vesical electrode*, is introduced while closed as in Fig. 78, and opened so as to clasp the neck of the uterus. One of the insulated wires is connected with the positive and the other with the negative electrode. By this means the current is very closely localized in the neck of the uterus.



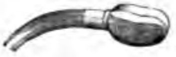


FIG. 78.

Concerning these internal applications of electricity to the uterus, it may be remarked :—

First—That in those cases where local treatment is indicated, more of the pain beneath the electrode which is applied on the back or abdomen, even when the negative, which is the stronger and more painful, is applied internally.

Tripier,* who has carefully studied the subject of localized faradization of the uterus, is accustomed to place one pole in the bladder by means of a vesical insulated electrode, or in the rectum by a rectal electrode.

In some cases he connects one of the poles with a bifurcated electrode, a branch of which is placed on each iliac region, while the negative pole is connected with an insulated rectal electrode in the rectum.

Recapitulation of method of localized electrization of the uterus and its appendages :—

1. Externally; one pole over the abdomen and the other on the lower part of the spine.

2. One pole in the rectum by means of an insulated rectal electrode, and the other over the abdomen, or connected with a bifurcated electrode, a branch of which is placed over the ovaries.

3. One pole is applied to the neck of the uterus by means of a uterine electrode, or in the cervix, or in the uterus by means of an intra-uterine electrode, while the other is applied (*a*) to the abdomen, (*b*) at the lumbar region of the spine, (*c*) at the abdomen and at the lumbar region of the spine by means of a bifurcated electrode, (*d*) in the bladder by means of a vesical insulated electrode, (*e*) in the rectum by means of an insulated rectal electrode, (*f*) in both the bladder and rectum by means of bifurcated conducting wires connected with the insulated vesical and rectal electrodes.

4. One pole is applied in the rectum by means of an insulated rectal electrode, and the other pole in the bladder by means of an insulated vesical electrode.

In all these methods of application either direction of the current may be used. As a rule it is best to apply the negative at the os or in the uterus, because it is the stronger and acts more promptly on the contractile fibre-tissue. (See p. 165.)

The vagina may be treated by a metallic vaginal electrode (Fig. 79), with which either the positive or negative pole may be connected. This is useful in *leucorrhœa* and *prolapsus*. For these local applications either the galvanic or faradic currents may be used; but the faradic is usually preferable, because in the majority of cases for which electricity is applied to the female sexual organs, *mechanical* more than chemical effects are indicated. Especially is this the case in amenorrhœa. Furthermore, the currents may be stable or labile, uniform or increasing, ascending or descending, according to the indications. Local applications to the uterus, whether external or internal, may be continued for from five to fifteen minutes. Several methods may be tried at each sitting. But very many, perhaps the majority of cases of functional disease of these organs, require *general* as well as localized electrization. There is no department in which so many mistakes have been made by too exclusively local treatment as in that of gynæcology. *No case of functional disturbance of the uterus should be abandoned by the electro-therapeutist until he has faithfully tried general as well as external and internal localized electrization.* To treat symptoms of central or constitutional disturbance by merely local electrization is illogical in theory and unsatisfactory in practice.

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* Annales de l'Electro-Thérapie, 1863, p. 205 et seq.

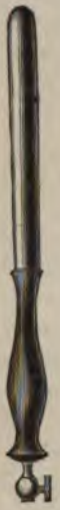

FIG. 79. Vaginal Electrode.

All the organs of generation in woman as well as in man can be affected by galvanization or even faradization along the spine. Besides general electrization, galvanization of the sympathetic should be tried in all obstinate cases. A strong evidence of the beneficial results of general electrization in these cases is the fact that patients undergoing treatment frequently remark that their menses are in some way affected. In some cases they are brought on before their time, in others much increased in quantity. So frequently does this happen that we prefer on the whole to suspend the treatment during the menstrual periods in those cases where no therapeutical effect is desired on the sexual organs.

The *time* of making the applications is not unimportant. It is an advantage, in amenorrhœa at least, to concentrate as many applications as possible during the few days that precede the appearance of the menses. And yet the advantage of this is hardly as great as has been supposed. The great thing in all but recent and temporary cases is to remove the anæmia or chlorosis, or nervous exhaustion with which the menstrual disorder is associated, and of which it is a prominent factor. Another suggestive consideration is that the menstrual flow may be brought on or increased through *reflex action* by localized electrization of other and distant portions of the body, as the hands, feet, chest, etc.

Statical Electricity (Franklinization) has been used for amenorrhœa, and with varying results. The very successful results of Dr. Golding Bird, in Guy's Hospital, have been indefinitely quoted, but have not been yet repeated to an extent sufficient to show that this form of electricity is superior to galvanization or faradization in the treatment of this affection. Others, however, as Holsbeck, Bitterlin, Taylor, Hervieux, and Graves, have reported cures by this method.*

Prognosis in Diseases of the Uterus.—Whatever method is used, generally requires time to insure results. While it is true that a single application, especially internal, may bring on the menses,—may even cause the blood to appear during the sitting,—yet in the majority of instances treatment must be more or less protracted in order to insure permanent relief. The very general impression that the object of electrization of the functionally diseased uterus is merely to *stimulate* the organ to its duty, is a great mistake. Electrization cures these diseases as much by its permanently tonic effects on the system, as well as by its temporarily stimulating effects on the organs themselves.

Of *amenorrhœa* we have treated 14 cases. Of these 8 recovered, 1 approximately recovered, 5 were not benefited.

Of *dysmenorrhœa* we have treated 7 cases. Of these 3 recovered, 2 were decidedly benefited, and in 2 cases the results are unknown.

We have met with no known case of absolute failure in nervous dysmenorrhœa, and the cases of recovery, as will be seen in the detailed cases, were quite remarkable.

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* Meyer, op. cit., 451.

Of *vaginal leucorrhœa* we have treated 4 cases. Of these 1 recovered, 2 were decidedly benefited, and 1 was not benefited.

Tripier* obtained good results from localized faradization. He reports that 3 cases of dysmenorrhœa and 4 cases of amenorrhœa recovered, and 2 cases of amenorrhœa and 2 of menorrhagia were improved. His cases were variously complicated.

ENLARGEMENTS AND DISPLACEMENTS OF THE UTERUS.

Tripier, Beuvain, Seiler, Fano, and Beau have experimented somewhat in the treatment of enlargements and flexions, and prolapsus of the uterus, by electrization. Both the galvanic and faradic currents were employed, chiefly the latter. The important chemical and mechanical results obtained by electrization in other parts of the body give reason to hope that on further trial it may realize some of the hopes that are expressed on this subject by Tripier and the other above-mentioned writers. A remedy that can discuss tumors (see Electro-Surgery), cause the absorption of fluid effused in hydrocele and rheumatic joints, should not be wholly powerless against enlargement of the uterus.

The results obtained in prolapsus uteri are probably to be explained partly by the chemical and mechanical effect of the current on the structure of the uterus, and partly by its tonic effects on the ligaments and vaginal walls. We have seen good results in the use of general and localized faradization as an adjuvant in several instances.

Treatment.—In the treatment of the various diseases of the uterus, the application must, of course, be varied with the morbid condition. Special rules cannot be given in any detail; each case must be studied by itself.

According to Tripier,† *chronic metritis* and enlargement of the uterus is best treated by applying the uterine electrode against the os, and connecting the other pole (bifurcated) with an insulated rectal electrode in the rectum and a sponge electrode over the abdomen.

Prolapsus uteri, the same author treats by applying the uterine electrode against the os, and connecting the other pole (bifurcated) with two sponge electrodes, one on each groin.

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* Annales de l'Electro-Thérapie, 1863, p. 205 et seq.

† Loc. cit., p. 38 et seq.

For *anteversion and anteflexion* he introduces the negative pole into the rectum, where it can act more powerfully on the posterior part of the uterus, and the positive in the vagina.

For *retroversion and retroflexion* he applies the positive pole in the bladder or over the abdomen, while the negative is applied to the os, by the uterine electrode, an air pessary having first been put into the rectum to elevate the fundus.

Whether the subject has yet been sufficiently studied to enable us to assign precise and exclusive methods of application for each special disease of the uterus, is, to say the least, questionable. More or less benefit may be derived from electrization in almost any form of displacement by any or all of the different methods of application. General electrization is sometimes of excellent service in such cases by its tonic effects on the system, while the effect of localized applications is to increase the *tone of the vagina and the ligaments, and diminish the engorgement.*

The treatment may be regarded as an important adjuvant in all rebellious cases of uterine displacement, and especially of those that are associated with general debility.

Prognosis in Uterine Displacements and Engorgements.—Tripier* details thirty cases of various phases and complications of uterine disease treated by localized faradization.

Of *anteflexion and anteversion*, 4 cases recovered, 2 were improved, and in one case no result was obtained.

Of *retroversion and retroflexion*, 1 case recovered, 1 was improved, and in 1 case there was no result.

Of *engorgement*, 2 cases recovered.

Tripier further *observed very marked effects on the general system, and severe symptoms of hysteria, neuralgia, and nervousness were greatly ameliorated.* If general faradization had been employed, these constitutional effects would have been much more marked.

INTRA-UTERINE GALVANIC PESSARIES.

The attention of the profession was called to the use of galvanic intra-uterine pessaries by Sir J. Y. Simpson. The instrument which he employed was composed of a piece o zinc and a piece of copper, fastened together into a shape and size suitable for entrance into the uterine cavity.

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* Annales de l'Electro-Thérapie, p. 202 et seq. 1863.

As thus constructed the instrument was stiff and unyielding, and was not adapted for the various states of uterine flexion. This form of pessary Prof. T. G. Thomas* has greatly modified by substituting for the single pieces alternate beads of zinc and copper, which are arranged on flexible wire inserted in a rubber bulb. (Fig. 80.) This instrument we still further modified by *insulating* the wire on which the beads of zinc and copper are strung, except at the extremities, where it makes metallic connection at one end with the zinc, and at the other with the copper bead, thus forming a miniature voltaic pile, with a completed circuit.

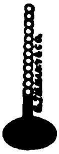

FIG. 80. Intra-Uterine Galvanic Pessary.

When this contrivance is closely embraced by the lining membrane of the uterus, and thoroughly moistened by the uterine fluids, a feeble current is unquestionably generated. In order to test this matter we tied around one of these galvanic pessaries a piece of fresh and moistened beef, and connected the extremities with a galvanometer. Immediately a slight deflection of the needle was observed. The experiment we repeated a number of times, and always more or less variation of the needle was obtained.

When, therefore, such a galvanic pessary is *in situ* it is not impossible that the very feeble current, as it passes through the metallic beads, may traverse, to a limited extent, the folds of the lining membrane of the uterus, which presses between them.

The question whether the very slight current thus produced, combined with the necessary mechanical effect of the metals in such case, is capable of important therapeutic results, can only be answered by extended experience and discriminating observation.†

Dr. Thomas assures us that in amenorrhœa positive therapeutical results have been obtained by the use of this pessary; but is unable to say whether the results are due to the mechanical effect of the metals or to the action of the current.

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* A Practical Treatise on the Diseases of Women. Second edition, p. 500.

† The white coagula that are observed after the application of this pessary are caused by the chemical action of the current on the intra-uterine fluids.

Dr. Peaslee also has seen favorable results from the use of the same pessary.

The question whether the therapeutical effects are due to the pressure of the foreign body or to the action of the current might be settled by substituting glass beads for the metals.

Dr. Murray, quoted by Althaus,* has used Simpson's intra-uterine galvanic pessary with success in cases of sub-involution of the uterus, where the os is open, the lips thickened, and whole organ flabby with excess of menstruation and disagreeable discharge. In one marked case a fortnight's use of this instrument reduced a flabby uterus "nearly to its normal and healthy condition."

Amenorrhœa—Anæmia and cardiac palpitation in a lady eighteen years of age—Two months' standing—Improvement of all the symptoms and reappearance of menses after eight séances of general faradization.

CASE 122.—In 1866, a young lady of eighteen consulted us for what she regarded as a disease of the heart. Her speech was only in broken utterances, and her breathing was short and rapid. She was decidedly anæmic, and had been troubled with amenorrhœa for two months. The patient was so hysterical that the first application was given with difficulty. Whenever the strength of the current was much increased, faintness was at once produced. After the first week, however, she could bear a current of odinary strength without discomfort.

The treatment was continued for one month—the patient visiting us every other day. By that time her apparent cardiac symptoms had disappeared; her breathing was more natural; her cheeks full of color, and her step more firm. Her menses returned after the eighth application.

Suppression of menses from sea-voyage—Immediate relief from external faradization.

CASE 123.—Miss D——, aged 25, was sent to us by Dr. James L. Brown, to be treated for suppression of the menses, caused by a sea-voyage five months previous. She was stout and vigorous, and complained of no other symptom. According to Dr. Brown's diagnosis, there was no organic uterine disease. We gave her a general application with the descending faradic current. The next day she said that some blood had appeared. The application was repeated, a strong current passing over the bowels and lower portion of the spine. A healthful flow for two or three days after she left the office.

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* Op. cit., p. 631.

Dysmenorrhœa and Menorrhagia—Anæmia—Debility—Remarkable sensitiveness to the current—Entire recovery under general faradization.

CASE 124.—A married lady, aged 33, was sent to us in the early part of 1867. Some ten years previously her husband had been the proprietor of a large boarding school, and the care and labor which devolved upon her as matron proved too much for her strength. Her health finally became so much impaired that the business was given up, and from that time she had been vainly seeking for permanent relief. There was prolapsus of the uterus of the first degree, and during the menstrual period she suffered from general neuralgic pains of a severe character. What she chiefly complained of and regarded as the principal source of ill health, was the excessive dysmenorrhœa and menorrhagia, which occurred regularly every month.

The catamenial flow continued seven days, during which time, and immediately afterward, she presented a remarkably weak and anæmic appearance.

In the intervening time and under favorable circumstances, she regained a portion of strength and color, only to be again prostrated at the menstrual period. Her previous medical advisers had given her tonics and other remedies most suited to her case, but what seemed to have given her greater temporary relief than anything else was a course of localized electrization, to which she had submitted in Boston. The menorrhagia and dysmenorrhœa seemed to be but a consequence of general debility; and indeed the symptoms of which she complained were so many and varied, that it was impossible to point out any one to which treatment should be especially directed. We immediately commenced general applications of an exceedingly mild and fine, or rapidly interrupted current. She was so susceptible to the influence of the electricity, that only the most gentle current could be borne; and, contrary to our general experience in such cases, she was at the completion of her course of treatment as little able to endure the sensation as at the beginning.

The applications were given from two to three times a week, and were continued about two months.

In her case as in many others, the first *séance* was followed by considerable nervousness and some soreness, but as she was instructed to expect such a result, it caused no uneasiness.

After two weeks of treatment her courses came on, and were as long continued and the loss of blood almost as great as ever. Her other symptoms, however, were considerably ameliorated, and the pain from the neuralgia was hardly noticeable. During the succeeding three weeks she appeared a different person.

Her appetite was exceedingly keen, her sleep refreshing, and she had the desire and strength to exercise daily in walking, to an extent which before would have exhausted her. We looked for a pleasant result as the time for her courses drew near, nor were we disappointed. The flow continued but four days, and the dysmenorrhœa and menorrhagia were so trivial as hardly to deserve notice, and the general neuralgic pains were wanting. Another result of the treatment was to restore the slightly prolapsed uterus to its normal position. This condition was evidently associated with relaxation of the vaginal walls, and the beneficial result that followed was due to the direct tonic effect of the current upon those walls, as well as to the general influence which was exerted over the whole system. She has had no relapse.

The points of particular interest attending the foregoing case were as follows:—

1st. It was absolutely impossible in making the applications to use effectively the sponge or any artificial electrode. From even the very finest and mildest current she would shrink, when it was passed through the sponge, *while a stream of much greater intensity was borne without much discomfort when it passed through the person of the operator, and was applied directly by means of the moistened hand.*

As is generally the case, we expected that she would become inured to the passage of the electricity, so that the amount could be increased, but at each succeeding sitting she seemed to feel its influence as much as at the first. But even this patient could bear, and needed more of the electric influence along the spine and over the vital organs, than could be given through the person of one not accustomed to the direct passage of the current.

2d. The second point of interest consists in the fact that she had previously been treated by *localized* electrization, and with some benefit, although not sufficient to encourage her to hope for a complete or even an approximate cure. We made use of *general* electrization only, and although the applications were directed to particular parts, longer and harder than to others, yet the main idea was to bring the system generally under the influence of the electric current.

Dysmenorrhœa from congestion of uterus in a lady of 22—Anæmia—Improvement under general faradization and localized galvanization—Relapse.

CASE 125.—Miss M——, a young lady of 22, was sent to us in August, 1867, by Dr. Moreau Morris, to be treated for a dysmenorrhœa of an unusually distressing character. She was of a frail nervous organization, and was decidedly anæmic. In the opinion of Dr. Morris, the dysmenorrhœa was caused by congestion of the womb, brought on by repeated colds and chills during the menstrual period, years before. From her girlhood she had been an invalid. Her appetite was exceedingly delicate, and there was great impressibility to disease in all her mucous membranes. It would indeed be difficult to conceive of a more disheartening case of dysmenorrhœa, for any kind of treatment.

Very doubtful encouragement was given. General faradization was chiefly employed.

It was not long before she began to improve in her general condition, and experienced a greater relief from her severe neuralgia and dysmenorrhœa than she had ever secured from internal medication. At one of her monthly courses she was almost entirely free from pain; and at most of the others that have occurred since she began treatment, she has suffered less than formerly. She is now far from being strong, but retains in a good measure the benefits she received.

Prolapsus, retroversion and laceration of cervix—Anorexia and debility—Faradization of uterus and vagina, and general faradization—Improvement of general condition—Very slight improvement in local disease.

CASE 126.—A married lady was sent to us by Dr. John T. Metcalfe, in order that she might receive the tonic effects of general electrization for a uterine difficulty of six years' standing. There was retroversion, and there had been at times considerable prolapsus, and also laceration of cervix. Her appetite was poor, her bowels very constipated, and her whole system was greatly weakened by severe and oft-recurring attacks of menorrhagia, not only at her periods, but on any exciting cause.

There was a very relaxed, flaccid condition of the vaginal walls, and of the whole genital apparatus. The improvement in her general condition was rapid. Her appetite increased; her bowels were regular from the beginning of the treatment; her severe neuralgic pains, that formerly were most distressing, were greatly mitigated, and what is of most importance, the menorrhagic attacks were diminished in frequency and violence. The local condition was not improved.

Neuralgic dysmenorrhœa and menorrhagia—Constipation—Permanent improvement under general faradization.

CASE 127.—Miss D——, aged 21, came to this city from Auburn, to be treated for the variety of dysmenorrhœa termed neuralgic. The treatment by ordinary internal medication was continued some two months, but, as the neuralgic pain seemed to be but little relieved, and as her general condition did not improve, she was induced to try the effects of general electrization before returning to her home. She commenced to menstruate at irregular intervals when about fifteen years of age, and from the first had suffered more or less at each menstrual period. Her general health began to fail some three years before she visited this city for treatment, and when she came under our observation she presented the following symptoms:—

She was decidedly anæmic, and the general appearance of lassitude and discouragement which she presented at once betrayed the disturbance of her vital forces. While in many instances of neuralgic dysmenorrhœa the pain seems to be confined solely to those nerves that supply the sexual organs, in this case the disorder extended to the whole system. The constant recurrence and terrible paroxysms of pain from which she suffered rendered life a burden. Even in the intervening time, anticipation of the agony that she again must so soon undergo, caused her to suffer from great depression and melancholy.

In addition to these distressing pains she suffered from profuse menorrhagia, so that what little strength she regained after her sickness was almost immediately lost on the return of the catamenia. Her bowels had been for a long time obstinately constipated, and unless this state were frequently relieved by aperients she was annoyed by considerable vertigo and headache. She began to despair of ever obtaining relief. She received the first application of general electrization in November, 1866. A very mild and fine current was used, and the application was extended from the neck down the spine and over the vital organs.

Although she was submitted to the influence of the current for but five minutes, yet during the application she showed symptoms of faintness, and on the following day she suffered from considerable soreness and nervous prostration. She visited us on three different occasions when her courses appeared, and were as long continued and attended with as great loss of blood as before. There was, however, considerable amelioration of pain. Before the cessation of the flow we renewed the operations, and continued the treatment uninterruptedly for nearly four weeks. She received an application every other day, and was soon able to bear a current of ordinary intensity. The improvement in her condition was exceedingly rapid. The capricious appetite became less exacting, and constipated bowels more regular. After a very few applications had been given and the influence of electrization began to manifest itself, she appeared a different person both in mind and body. When her menses again appeared she suffered but little more pain than is usual, and the general neuralgic distress was quite wanting.

The menorrhagia, which before was such a prominent and debilitating symptom, was now so slight as scarcely to deserve the name. She received subsequently three more applications, when she returned to her home. We were of course anxious to know if this favorable state of things continued, and have been gratified to learn by direct information that since she discontinued treatment there has been no return of any prominent distressing symptom. She moreover continued to improve in her general condition, until she became robust.

Prolapsus uteri—Leucorrhœa and menorrhagia—Loss of tone in vaginal walls—Recovery under faradization of uterus and general faradization.

CASE 128.—Miss T——, an unmarried lady, aged 30, applied for treatment for falling of the womb of the second degree, from which she had suffered for nearly six months. Previous to the first symptoms of prolapsus, persistent leucorrhœa had annoyed her for some time, and had continued up to the day she came to us. She complained also of some menorrhagia. These conditions, however, were evidently associated with no organic uterine disease; but her general health was quite feeble. If it were a case for electricity at all, it was plain that she needed its tonic influence. We commenced, therefore, with mild general applications, increasing the strength of the current at each visit as she was able to bear. At each sitting, also, the electrode was applied for a few minutes against the os and the vagina. The beneficial results of this course of treatment were soon observable. Her appetite, which had been capricious, became more rational, and her strength increased with marked rapidity. The vaginal walls seemed to gain tone day by day, until after the sixth application the uterus was restored to its normal position.

Neuralgia and leucorrhœa with chronic diarrhœa, with debility—Spinal irritation—Improvement under general faradization.

CASE 129.—Mrs. P., a married lady, 35 years of age, first applied to us for electrization in May, 1867. She stated that a protracted and painful labor three years before had so reduced her that she had never been able to regain her strength.

She complained of general weakness, poor appetite, and inability to make any exertion. She suffered almost constantly from pain in the back, and from acute neuralgic attacks in the top of the head.

She had all along suffered more or less from a leucorrhœal discharge, and for about six months before we saw her she had been growing weaker and weaker. On examination per vaginam we found an indurated os, the result of chronic inflammation, and slight prolapsus. She was, in a word, a typical case of special and constitutional weakness that we so often meet in females in the better walks of society. In this, as in the previous case, internal medication in the shape of iron, quinia, strychnia, etc., had been tried by her skilful medical adviser so perseveringly and so uselessly that we resolved to discontinue it altogether. Even at the first sitting she was able to bear a good strength of the current, except on the top of the head and over the transverse colon. There were no unpleasant secondary symptoms; she slowly but steadily improved in her general condition and in her special symptoms. The diarrhœa was checked, and the stools gradually assumed a more healthy appearance; and with this improvement in the condition of her bowels, the tender spot over the transverse colon became less sensitive to the current. On account of her diarrhœa the had been forced to be very scrupulous in her diet, but she could now eat all she common articles of food with impunity.

She could sleep freer and longer than before, and had gained very perceptibly in strength and color. Her headaches were the symptoms last to yield, but they diminished in their violence and frequency. The treatment was extended over a period of two months.

Amenorrhœa—General condition excellent—Permanent recovery under the alternate use of faradization and galvanization.

CASE 130.—Mrs. S., a widow lady, aged 28, had not menstruated for more than a year. The complaint was as persistent as her general health was perfect, for she apparently suffered from no ailment, with the exception of a slight leucorrhœa which readily yielded.

The faradic current alone was applied every other day for several weeks, but without benefit. On two different occasions, therefore, we made use of the galvanic current from a voltaic pile of 90 pairs, placing one pole over the sacrum and the other over the region of either ovary alternately. The faradic current (localized) was again made use of twice, at intervals of two days, when the catamenia came on and continued several days. She passed the next period without being unwell, and so we directed her to come again about a week before the day when she expected her courses. She received a general application of the faradic current every other day, and at the expected time her courses appeared. Nearly two years have now elapsed since she discontinued treatment, but she is still regular.

In the treatment of most of our cases of amenorrhœa by electrization, we have been guided by the general principle which we consider established—that general electrization with the faradic current is a constitutional tonic—and the result has been more satisfactory than we anticipated.

In the above case no apparent debility existed, and the cause may possibly be ascribed to a torpid condition of the vaso-motor nerves of the ovaries and uterus. This may account for the improvement under general faradization.

In all such conditions the galvanic current may possibly prove more efficacious than the faradic.

The following case illustrates the advantage that may be derived from internal and intra-uterine faradization when external applications fail.

Amenorrhœa by intervals for several years—Relief of suppression by intra-uterine faradization with a powerful current, after failure of external applications, and also of applications to the os by the uterine electrode.

CASE 131.—Miss S., aged 23, was sent to us by Dr. Fordyce Barker, July 6th, 1870. During all her menstrual life she had been more or less irregular.

At various times she had been relieved by faradization of some kind, and had found by experience that it was necessary to use internal applications. Her general condition was not of the best, and suppression always brought general nervous derangement. At this date she was three or four days past the time for her menses. We treated her at first by the uterine electrode (connected with the negative pole) against the os, and the positive either on the abdomen or lumbar region. This treatment, repeated four times, brought on some appearance of blood, but not the free menstrual flow. One application with the same strength of current with the intra-uterine electrode (p. 493) for about the same time—10 minutes—brought on a profuse flow on the day following, and the patient was no longer treated.

In addition to the local treatment, this patient needed also general faradization during the intervals, to tone up and fortify the system, so that attacks of suppression might less easily arise.

CHAPTER XXX.

DISEASES OF THE MALE GENITAL ORGANS.

THE medical diseases of the male genital organs, for which electrization is chiefly indicated are *spermatorrhœa*, *seminal emissions*, and *impotence*.

True spermatorrhœa—that is, involuntary discharge of semen without erection—is less frequent than is commonly believed. Through the activity of charlatans and the indifference of the profession, the community have been educated to such erroneous ideas on this subject, that young men who find a drop or more of fluid at the mouth of the urethra in the morning are terribly alarmed, and in time frequently become hypochondriacal to the last degree. We frequently find it necessary in such cases to have a portion of the discharge submitted to a microscopical examination, even when there is not the slightest reason to suspect the presence of spermatozoa, in order to convince the patient that the seminal fluid is not running away from him. There are those who, even after this final test, prefer the evidence of their suspicions, and refuse to be comforted until by proper local treatment the discharge is made to cease.

Seminal emissions—that is, involuntary discharge of seminal fluid, with erection—can only be regarded as a pathological condition when it becomes so frequent as to affect the health. Constitutions vary so widely in their relation to the seminal secretion, as to all other physical functions, that it is impossible to assign any definite or mathematical limit within which involuntary discharges of semen in the unmarried is to be regarded as a physiological condition. It is probable, however, that for the majority some local or general pathological condition is indicated when the emissions appear oftener than once or twice a month. But when the emissions are far more frequent than this, marriage alone is oftentimes a satisfactory cure.

The question whether special treatment is required in any case of seminal emissions, is to be decided not so much by their mathematical frequency as by the physical or mental condition with which, as cause or effect, or as both combined, they are associated.

Cases that are accompanied by pain in the back and limbs, dyspepsia, constipation, insomnia, debility, and indisposition to mental or muscular labor, though sometimes relieved or cured by marriage alone, yet usually require some form of general and local treatment. The need for treatment in such cases is the more imperative since marriage is a prescription of which comparatively few can at once avail themselves. Cases that are associated with psychical disturbances—melancholy, foreboding, hypochondriasis, and self-brooding—also require hygienic and medical as well as strongly moral treatment, even though their general condition in other respects is undisturbed. The hypochondriasis of such patients, though it may be sometimes dispelled, by disabusing the mind of error, and by other measures that tend to give comfort and reassurance, is yet oftentimes apparently a disturbance of the central nervous system, and requires treatment accordingly. Morbid sexual desires, that sometimes complicate seminal emissions, demand and are much benefited by electrization. Patients in this condition are excited to an erection, and sometimes to discharge of urethral fluid, by the sight of a female, by the reading of exciting books, or by any cause that mechanically irritates the parts, as riding in the cars or stages.

Both spermatorrhœa and seminal emissions may be caused by any influences that tend to weaken the system—masturbation, excessive sexual intercourse, prolonged continence, or exhausting diseases. Masturbation is most injurious when practised in early years; and the worst victims of seminal emissions are those who suddenly break off the habit in which they have excessively indulged since the dawn of puberty. Cases that arise from exhausting diseases, as fevers, etc., usually recover with the improvement in the general condition.

Treatment.—Usually local, but sometimes general treatment, is required.

External method.—The testicles may be placed directly between the poles, with gentle pressure. The testicles and perinæum are less sensitive to external applications than any other portion of the surface of the body, except the middle of the back.

The vesiculæ seminales and the testicles may be affected, and in some patients very powerfully and sensibly, when one of the poles is applied to the lower part of the spine, and the other to some point on the thigh or against the perinæum. A very good way to affect the male reproductive organs is to apply one pole firmly against the perinæum, and the other upon the testicles.

Faradization of the genital organs should not usually be protracted longer than five to ten minutes; galvanization from two to eight minutes. For external electrization the faradic current would appear to be preferable.

Internal method.—Besides these applications, seminal emissions and spermatorrhœa may require the use of an insulated catheter electrode (Fig. 81) that may be applied directly against the ejaculatory ducts or in their vicinity. This catheter electrode may be connected with the positive pole (see p. 165), while the negative is applied along the spermatic cord, at the perinæum, or on the lumbar vertebræ. This method of application should usually be made with the galvanic current of moderate strength. The sitting should not be prolonged beyond three or four minutes, and should not be too frequently repeated, lest it may over-irritate the parts. An average of once a week is sufficient for this method of internal application, while the external applications in their different varieties are used daily or every other day, or twice a week. The *vesiculæ seminales* may be electrized by the application of an insulated rectal electrode against the anterior wall of the rectum.

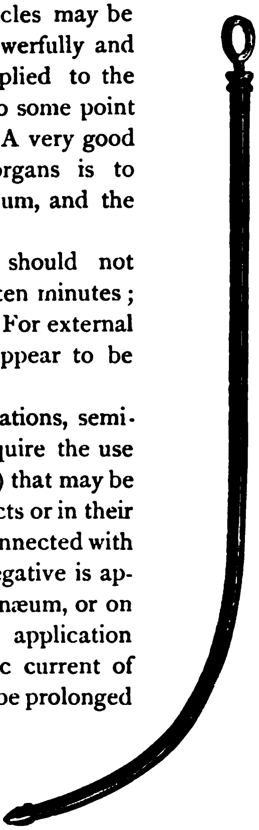

FIG. 81.
Insulated Catheter Electrode.

We have found the use of bougies to be of excellent service in these cases as a preliminary treatment, since it prepares the way for the electrization of the orifices of the ejaculatory duct by means of the insulated catheter electrode; and furthermore, of itself it exerts a remedial influence.

When anæsthesia exists it is best occasionally to use the electric brush with a strong faradic current.

Usually nothing is gained by very prolonged applications to the genital organs.

Cases that are accompanied by marked debility and mental disturbances, require general as well as localized electrization. We have seen patients improve under general electrization alone, when no special reference was given to the local difficulty. In cases of obstinate hypochondriasis, galvanization of the sympathetic should be tried. The dependence of the reproductive function on the brain and spinal cord and sympathetic is so intimate, that any beneficial influence directed to these parts may be directly felt by the genital organs themselves.

Electro-diagnosis.—Anæsthesia of one half, usually the left, of the penis, is a condition not unfrequently observed in diseases of these parts. This may be detected by an electric examination or by the æsthesiometer. This peculiarity, which was first pointed out by Schulz,* we have observed in a number of instances. With anæsthesia there may be coldness and blueness of the sexual organs. *Hyperæsthesia* of the urethra is a condition that is sometimes observed, especially in patients otherwise nervous and irritable.

Prognosis.—Seminal emissions and spermatorrhœa are so frequently complicated with other conditions, and are so liable to be kept up or aggravated by evil habits, that uniform results are not to be expected from any method of treatment. Electrization is oftentimes very successful, and occasionally obtains immediate results, but usually requires time and patience. The symptoms are prone to relapse, and not until after a number of weeks is it possible to decide how much benefit has been received. Under the combined and judicious use of localized and general electrization the majority of cases can be more or less benefited.

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* In order to detect the slightest anæsthesia of the penis, it is necessary to be familiar with the normal sensitiveness of the organ (see p. 255). At the end it is quite sensitive; this sensitiveness diminishes towards the root. The inferior surface throughout its whole extent is more sensitive than the superior. Benedikt affirms that the right half of the penis and the right spermatic cord are less sensitive than the left.

In cases where there is morbid sexual desire—the result of abnormal irritability of the parts—one of the first signs of improvement is abatement of this symptom. The patient is sometimes alarmed by this abatement, and unless the explanation is made, he may fear absolute impotence.

We have treated 12 cases of spermatorrhœa and seminal emissions, some of which were and others were not complicated with some grade of impotence; of these 4 cases recovered, 4 were decidedly benefited, 1 was slightly benefited, 2 were not benefited, and in one case the result is unknown.

IMPOTENCE.

Impotence manifests itself by the following symptoms:—

1. *Premature ejaculation of semen.*—With this symptom the sexual desire and power of erection may be normal or diminished, or in some cases may be abnormally active. Cases of premature ejaculation, accompanied by abnormal sexual desire, are obstinate to treatment on account of the difficulty of holding the patients in proper restraint. Certain chronic diseases of the spinal cord, as locomotor ataxy, are sometimes attended in their early stages with unnatural and excessive activity and capacity of the sexual function, which may or may not coexist with full power of ejaculation. A morbid irritability of the sexual organs may precede any of the phases of impotence.*

Premature ejaculation of semen may take place after or before entrance into the vagina. The condition is pathological whenever the ejaculation systematically appears too early. The quantity of seminal fluid in such cases may be either normal or diminished. Premature ejaculation of semen may be said to proceed from the same pathological condition as seminal emissions.

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* It is a noteworthy fact that certain diseases of other organs, as the brain and stomach, may be attended in their early stages by unnatural activity or exaltation of function. Thus the forming stages of insanity are sometimes preceded and foreshadowed by unusual activity and brilliancy of mind, and in dyspepsia morbid appetite is frequently a prominent symptom.

2. *Diminution or impairment of sexual desire and power of erection.*—Patients with this form of the disease complain that they cannot indulge in the sexual act as frequently as usual, or that their powers fail them at the important moment. The seminal fluid may be diminished in quantity on account of the diminished activity of the testicles, or in some cases may also deteriorate in quality. In such cases the ejaculation may be normal and the enjoyment as intense as usual: the abnormal symptom being incapacity to indulge in the act as frequently and with as much confidence as formerly.

3. *Entire absence of sexual desire and power of erection.*—This form of impotence arises from local paralysis, from disease of the brain and spinal cord, or it may be congenital. It is sometimes merely an advanced stage of the two symptoms previously named. In patients thus affected the seminal secretion is reduced to a minimum, and from long disuse the testicles and penis may become more or less atrophied.

4. *Psychical or imaginary impotence.*—This malady, so familiar to all medical advisers, and so distressing to its subjects, is most frequently found in young men who contemplate or desire marriage. Ignorant of what the normal sexual appetite should be, they oftentimes suppose that in their case it is deficient. Depressed and distracted by self-brooding, they sometimes fulfil their own dark forebodings, and fail in the preliminary attempts to accomplish the sexual act through the very intensity of their desire.

Causation.—Impotence in one or two of its forms certainly is frequently but a more advanced stage of *seminal emissions*, and is brought on by the same general causes—masturbation, excessive sexual indulgence, prolonged continence, or by any influence that debilitates the system. The third variety—entire absence of sexual desire and power of erection—is a very frequent result of chronic disease of the spine, congestion, meningitis, myelitis, degeneration of the posterior columns (locomotor ataxy), etc. The early and formative stages of spinal disease may be accompanied also by the first and second varieties. The worst cases are sometimes of congenital origin. Impotence may also result from purely local or peripheral causes. One of our cases was evidently of traumatic origin. In another a too prolonged galvanization of the urethra caused an impotent condition which, though temporary, was very alarming to the patient. The theory is admissible that impotence may be of a reflex character.

Electro-diagnosis.—Electric examination in cases of impotence sometimes reveals anæsthesia of one side of the penis, or hyperæsthenia of the urethra, as in seminal emissions. In the worst stages there may be atrophy of the testicles and of the penis, blueness of the parts, and great diminution of temperature, that is at once perceptible to the hand.

Treatment.—The electrical treatment of impotence may be local, central, or general. (The method of local electrization of the genital organs given under seminal emissions (p. 511) need not be here repeated.)

Internal applications are not demanded, except sometimes in the treatment of the worst form. In the local treatment special attention should be given to the parts supposed to be mostly at fault. Thus, diminished seminal secretion should be treated by stable galvanization or faradization through the testicles; premature ejaculation through the perinæum and symphysis pubis, or occasionally by internal applications with the insulated catheter electrode.

Central applications should be directed to the head, spinal cord, and sympathetic. The disease so frequently arises from, or is associated with, central disease, that central galvanization or even faradization alone is sometimes immediately beneficial without any local treatment whatever.

General electrization is indicated for those cases that are accompanied by symptoms of constitutional debility, anæmia or neurasthenia. General, like central electrization, is of great service in the treatment of impotence, even without the aid of local applications. Indeed our attention was first called to the special subject of the treatment of these conditions by the fact that patients affected with other diseases, and whom we treated by general electrization, remarked a surprising increase of sexual power, even when no attention was directed to the genital organs.

The earliest recorded case of successful treatment of impotence by electricity dates back to 1803, when Westring of Sweden reported a cure in two weeks of a patient 36 years of age, by means of the voltaic pile, which had been discovered three years previously.' In 1845 Stacquez reported a cure of a case of several years' standing, in a patient 35 years of age, by means of a Leyden jar. Since that time impotence has been successfully treated with the faradic current by Duchenne, with the galvanic current by Schultz and Roubaud, Benedikt,* and Althaus.†

Prognosis.—Surprising as it may seem, the prognosis of impotence, except the worst stage, under electrical treatment is better than that of spermatorrhœa and seminal emissions. This anomaly is accounted for by the fact that impotent patients, from the very nature of their malady, are unable to counteract the good effects of treatment by abuse of the organs; the exception to this rule is in impotence of the first form, attended with morbid sexual desire. In impotence as in seminal emissions, improvement in cases associated with abnormal excitability is first shown by diminution of the unnatural desire. Cases not too long standing, and not depending on incurable central lesion, frequently recover rapidly. As a rule, the younger the patient, the better the prognosis. Cases of a local origin, that are obstinate against all treatment, are the exception. Cases that result from chronic diseases of the spine must share in the fate of those diseases, and improve or retrograde with them. To sum up, in a word, we may say that the results of electrization in cases of impotence are such as to make it indispensable for those cases that fail to recover spontaneously or by general tonic medication.

Of 11 cases of impotence of which we have record, 3 recovered, 1 approximately recovered, 2 were decidedly benefited, 2 were slightly benefited, 1 was not benefited, and in 2 cases the results are unknown.

Aspermatism.—This term was first proposed by Roubaud in

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* Elektrotherapie, 454.

† Medical Electricity, second edition, p. 621.

1855, to describe a condition when the *power of erection exists without the power of ejaculation of semen.* The semen may be secreted, and the patient may even be annoyed by involuntary emissions. Dr. William H. Van Buren, in a short article on this subject,* suggests the theory that the difficulty in ejaculating the semen is caused by "an exaggerated spasmodic contraction of the muscular fibres in the walls of the ejaculatory ducts, leading to their occlusion under extreme excitement."

If this theory, which is surely plausible, be accepted, then galvanization and faradization of the orifices of the ejaculatory ducts would be indicated in this affection.

Reasoning from analogy, electrization of the testicles ought certainly to increase the seminal secretion ; and we feel confident, from the statements of patients and results of treatment, that it does produce this result, although the belief is one that is quite difficult of mathematical demonstration. We know that the electric currents applied around the neck increase the salivary secretion, and when applied through the mammary glands of nursing women markedly increase the lacteal secretion. That electrization of the liver increases the flow of bile we have several times demonstrated in cases of jaundice (see p. 487), since under even a shorter course of treatment the stools resume their natural color, and the yellowness disappears from the skin and conjunctiva. That electrization can increase the lachrymal nasal secretion any one can readily demonstrate by making a short application to the eyes and nose. That electrization can also increase the urethral secretion we have shown in two very striking cases. These remarks apply to both the galvanic and faradic currents.

Premature ejaculation of semen, probably resulting from early masturbation and gonorrhœa —Hyperæsthesia of the urethra—Improvement under successive treatments of general and localized faradization and galvanization.

CASE 132.—Mr. ——, aged 24, consulted us Sept. 3d, 1867, complaining of inability to perform the marital act with full satisfaction. The emission came too soon, and his wife was not satisfied. He had been quite recently married.

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* *New York Medical Journal*, November, 1868.

His desire was strong, and there was on his part considerable enjoyment of the sexual act. The patient was hypochondriacal, dyspeptic, and constipated.

The little discharge that appeared at the end of the penis in the morning, was, for his reassurance, submitted to Dr. Wm. B. Lewis for microscopical examination. No spermatozoa were found. The patient was treated by general faradization for his nervous irritability and hypochondriasis, and by local faradization and galvanization for his local affection. In all, twenty-five applications were given at different intervals and in different courses of treatment.

The results were not at once satisfactory. The patient was so self-absorbed, that whatever good effects might come from the treatment were counteracted by his evil imaginings.

The final result was quite decided, and when last heard from the patient remained improved.

Diminution of power of erection—Seminal emissions—Incontinence of urine—Slight anæsthesia of left side of genitals—Approximate recovery under local galvanization and faradization, and galvanization of the sympathetic.

Case 133.—Mr. ——, aged 30, unmarried, consulted us in December, 1869. He complained that he was unable to perform the sexual act as frequently as formerly; that seminal emissions frequently appeared. He had greatly abused his sexual organs. His general condition was fair, and his constitution strong.

Electric examination of the genitals showed slight, but perceptible anæsthesia of the left side of the penis.

The patient attended two or three times a week for three months. Various methods were used;—external faradization, galvanization of the genitals, internal galvanization with the insulated catheter electrode, galvanization of the spine and of the cervical sympathetic. Faradization with the metallic brush was employed. The anæsthesia soon disappeared, but the improvement in the other symptoms was slow. The patient occasionally tested his powers, and in the course of two months remarked decided advance, although he was at one time considerably discouraged by the fact that on passing a half hour with a prostitute he was unable to perform the sexual act at all. This difficulty was not observed when he subsequently spent the entire night with a woman. His seminal emissions became less frequent, and finally ceased to become a pathological indication. The final result of the treatment was, we believe, entirely satisfactory.

Premature discharge of semen without pleasurable sensation; apparently resulting from sexual excesses and secondary syphilis—Slight temporary but no permanent improvement under faradization—Improvement from galvanization.

Case 134.—Mr. ——, aged 28 or 30, referred to us by Dr. Buck, in December, 186), represented that in sexual intercourse the discharge appeared almost instantly after entrance into the vagina, and with scarcely any sensation of pleasure. He had suffered from secondary syphilis, and had committed great excesses. Faithful local treatment with the faradic current did very little good. The patient soon returned and was treated by galvanization of the genitals with strong currents, with slight improvement.

Impairment of sexual desire; associated with spinal weakness, dyspepsia, insomnia—Marked increase of desire after treatment by general faradization.

CASE 135.—A gentleman of 50 years of age, a widower for several years, of spare habit and nervous constitution, was referred to us in April, 1868. Besides the general symptoms of nervous exhaustion, insomnia, dyspepsia, the patient represented that his sexual desire was so far abated as to cause him considerable alarm. There was at times quite severe pain in the lumbar region, which was probably caused by hyperæmia of the cord. We treated him by general faradization daily for four weeks, giving special attention to the spine and genital organs. Relief to the pain in the back followed each sitting, and at the end of two weeks he declared that his sexual power had increased so much that he preferred to have no more attention given to the genital organs. The subsequent treatment was directed to the dyspepsia and insomnia, with moderately satisfactory results.

In this case the enfeeblement of sexual desire was doubtless caused mainly by the morbid condition of the spinal cord, and by the general exhaustion There is little doubt that the results of the treatment in increasing the sexual appetite would have been the same if no special attention had been given to the genitals.

Neuralgia of the neck of bladder following gonorrhœa—Treated by local faradization—No relief of the disease, but marked increase of the sexual power.

CASE 136.—Mr. ——, an English gentleman, 40 years of age, was directed to us to be treated for a kind of neuralgia of the neck of the bladder. He was stout, finely formed, very muscular, and in all respects healthy, save the almost constant but not very severe feeling of pain and irritability proceeding from the neck of the bladder towards both thighs. He referred the difficulty to a bad attack of gonorrhœa a number of years previously, but there was no difficulty in voiding urine, and examination with the sound revealed no stricture. As the patient was in excellent health we employed mostly partial applications with the faradic current, placing the positive pole above the pubes, or pressing it firmly against the perinæum, while the patient stood on a sheet of copper, to which was attached the negative pole. Sometimes we localized the current around the neck of the bladder as nearly as possible by placing one electrode against the prostate and pressing the other over the pubes.

The result of this treatment, so far as relieving the irritability of the neck of the bladder was concerned, was not satisfactory. The patient received but four or five applications, and becoming disheartened because a disease of fourteen years' continuance did not yield in as many days, abandoned the treatment. He reported, however, immediately after the first application, that there was considerable increase of the sexual power, and that the quantity of fluid secreted was greater than usual. He remarked the same at each succeeding application, although the electrodes were not applied directly to the testes. Other patients upon whom we have employed general electrization for various affections have made substantially the same confession. Therefore we seem to be justified in inferring that the same effects are experienced and realized by many who do not care to acknowledge it.

Chronic irritability of bladder, with debility, treated by general faradization, with special reference to the genital organs—Very marked increase of sexual power.

CASE 137.—Mr. ——, aged 38, of medium height and very spare, came to us in October, 1866, desiring to test the power of electrization for a chronic irritability of the bladder that had harassed him at intervals for several years. The amount of pain was not great, but there were perpetually recurring attacks of uneasiness in that locality, and sometimes after standing many hours (he was a bookkeeper) there was a sense of weight and heaviness that kept him in a disagreeable state of consciousness of the existence of his genital system. His general health was only fair, and we decided to make the applications general. Accordingly, he placed his feet on the sheet of copper to which the negative pole was attached, while the moistened hand was applied over the body from the head to the feet. The immediate effect was to subdue the local irritation, and exhilarate the entire system, so that the patient left the office in excellent spirits. He returned again in three weeks, and reported there had been some recurrence of the difficulty, but that, on the whole, he had felt better. The sexual appetite and power had been so much increased as to excite his wonderment. He continued to visit us from time to time for a number of weeks, with a repetition of the same effects, viz., relief of the irritation and increase of sexual power. In this case we sometimes applied the sponge directly against the scrotum.

Diminution of power of erection in a married man in the prime of life—Cephalalgia and debility—Recovery under general faradization.

CASE 138.—Mr. ——, a merchant in the prime of life, and to all appearances enjoying excellent health, consulted us for inability to perform satisfactorily the act of coition. This inability did not involve an absence of sexual desire, but simply a want of power to obtain and retain an erection. This gentleman had a family of several children, and since his marriage, many years before, had led, according to his statement, a correct and regular life. He attributed this premature decline to early excessive indulgence and abuse of the generative function. His outward appearance belied his general condition, for he suffered much from headache, and oftentimes, on rising in the morning, from considerable enervation.

General electrization was decided on and given, together with local applications. He continued treatment for three weeks, receiving an application every other day. The result was entirely satisfactory. His general condition was so much improved, and the vigor of his sexual organs was so much increased, that he was enabled to complete the marital act as satisfactorily as in his youth.

Impotence of twenty years' standing caused by local paralysis—Numbness and coldness of the parts—Deficient power of erection—Slight seminal secretion—No improvement under galvanization and faradization.

CASE 139.—Mr. ——, aged 44, was sent by Dr. Jerome Smith to be treated for impotence of nearly twenty years' standing. When but 17 years old he contracted gonorrhœa, and at the age of 25 was attacked by syphilis. At that time he led a very dissipated life, and no sooner was an attack of this disease apparently cured than he forthwith subjected himself to another. During the last attack the solid caustic had been introduced into the urethra. This cauterization produced excessive inflammation and pain, and was followed by complete impotence, associated with a feeling of numbness and coldness in the penis. He had tested nearly all remedies, and at one time, by the advice of Dr. Brown-Séquard, he had used hot and cold douches, but all without avail. When he came to us the penis was quite cold, and much below the natural size. Erection was occasionally possible, but he was never able to accomplish the marital act. The testes were of an almost natural size, and when the penis was artificially excited, a small amount of semen would appear. The penis was apparently paralyzed, and the impotence was manifestly due to that cause more than to the want of seminal secretion. The patient was a stout, hardy, vigorous man, of a full habit, and quite a free liver, and neither in his countenance nor in his general bearing betrayed the slightest effects or even consciousness of his affliction.

Four applications of the faradic current were given, with the effect of temporarily increasing the warmth of the penis, and nothing more. The galvanic current was then tried. It increased the circulation in the penis, and consequently heightened the temperature more than the faradic current, but no permanent benefit resulted. Our patient then discontinued the treatment, owing to the pressure of his business engagements. He would have persevered, however, if we had felt warranted in holding out reasonable chances of a successful result from a long course of electrization.

Premature discharge and deficient secretion of semen, caused by excessive sexual indulgence—Recovery under external and internal galvanization and faradization, combined with medical treatment.

CASE 140.—Mr. ——, aged 27, formerly a gymnast and latterly a printer, consulted us in May, 1870, for sexual weakness brought on by abuse of the organs. The discharge was premature, and with less excitement than usual, and there was a manifest deficiency of secretion. The patient was exceedingly muscular, and his general health was almost perfect. For that reason only local treatment was employed. The organs were faradized in the various methods twice a week, and once a week internal galvanization was employed, the metallic extremity of the catheter electrode being directed as near as possible to the orifices of the ejaculatory ducts. At the same time the patient was directed to take a mixture of bromide of potassium and wine of ergot. Under this combined treatment the recovery was complete in twenty-five applications.

During the latter part of the treatment the patient observed, during sexual intercourse, a very great increase in the quantity of semen discharged. This might partly be attributed to the current, since the bromide of potassium would have a contrary effect.

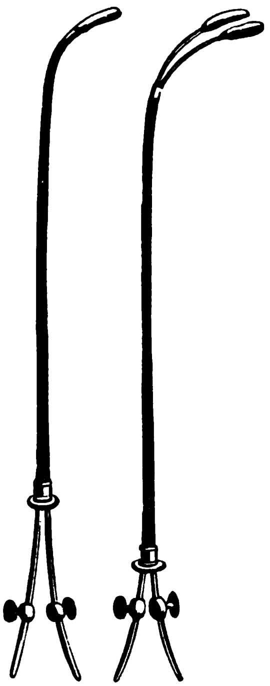
DISEASES OF THE BLADDER.

The diseases of the bladder for which electrization is chiefly employed are *incontinence of urine* and *paralysis.*

Incontinence of urine depends on an irritable condition of the neck of the bladder. While it largely sympathizes with other diseases and the general health, being frequently associated with hysteria and spinal irritation, it is yet oftentimes a purely local affection. There are various grades of the disease, from simple irritability that makes it necessary to pass the water with unusual frequency, to utter inability to sleep through the night without unconsciously "wetting the bed." The former condition exists mostly in adults —especially in the hysterical and the aged; the latter is peculiar to the period of childhood. It is probable that the pathological condition in children who nightly void their urine in bed, is not necessarily worse than that in adults who only complain of being obliged to pass the water with abnormal frequency. The unpleasant results in children are due to their profound sleep or deficient self-control. That the pathological condition in children is not always of an important character, is proved by the fact that it sometimes yields to purely moral influences.

In the treatment of incontinence of urine, both external and internal applications may be used. In the majority of cases the internal applications by means of the catheter electrode (p. 511) are not required. It is needless to say that in young children the introduction of the catheter electrode is attended with difficulty. The treatment we prefer is faradization with strong currents through the neck of the bladder. In males one pole may be placed over the symphysis pubis, and the other at the perinæum; in females one pole may be applied over the symphysis pubis and the other at the lower part of the sacrum. Cases associated with hysteria, or dependent on spinal disease, need central and general electrization.

Prognosis.—The prognosis of young and recent cases is usually good. Long standing cases also yield, but need correspondingly longer treatment. Cases complicated with constitutional or central disease, which are, of course, mostly found in adults, have either a favorable or unfavorable prognosis, according to the nature of the malady with which they are complicated.



CLOSED. OPEN.

FIGS. 82, 83.—Double Vesical Excitor or Electrode (Duchenne).

Paresis and paralysis.*—Paresis and paralysis of the bladder so frequently depend on incurable diseases of the spine, that the prognosis is, as a rule, unfavorable as regards a complete cure. Relief and improvement, even in very bad cases, may be gained by faithful treatment, but entire recoveries are exceptional.

The *treatment* should be external and internal, with both the galvanic and faradic currents, combined with central galvanization.

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* From παρεσις, exhaustion.

External applications may be made, placing one pole, the negative, over the symphysis pubis and the other on the back, and passing very strong faradic currents with interruptions.

Internal applications may be made either with the insulated catheter electrode, or with Duchenne's double vesical electrode (p. 523).

The catheter electrode may be connected with the negative pole while the positive is at the hypogastric region or back. By means of the double exciter of Duchenne the current can be more exclusively localized in the muscles of the bladder than by any other method.

DISEASES OF THE RECTUM.

Electrization has been used for *prolapsus ani*, *paralysis of the sphincter*, and *hæmorrhoids*.

The current can be very well localized in the rectum by means of a rectal electrode (see p. 484), which may or may not be partly insulated. The rectum may also be treated by a double rectal exciter, analogous to that which is used in the bladder. When a single electrode is used, one of the poles should be placed on the spine.

Prognosis.—Paralyses of the sphincter that depend on local disease, like paralysis of the bladder depending on the same cause, rarely offer a perfectly favorable prognosis.

In *prolapsus ani* Benedikt* claims a few mostly good results.

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* Op. cit., p. 482.

CHAPTER XXXI.

DISEASES OF THE LARYNX.

THE disease of the larynx, for which electrization has been almost exclusively used, is *aphonia*, a condition which arises from many morbid states.

ANÆMIA AND INFLAMMATION.

It is true that external electrization of the throat is of service as an adjunct in the treatment of inflamed and irritable conditions of the larynx, but only in rare cases has it been thus employed. We have found that faradization of the neck, for from two to five minutes, has an appreciable and agreeable effect in diminishing the irritation produced by cauterization, and when continued exerts a tonic influence on the organ. In cases of diseases of the larynx, connected with hysteria or anæmia, the local treatment is materially aided by general electrization.*

Subacute and chronic inflammations of the pharynx are also treated with some success in the same way, and on the same principles.

Method of external electrization.—The larynx may be electrized externally by various positions of the electrodes. One pole may be placed at the back of the neck and the other just above the manubrium sterni, or the poles may be pressed against the larynx by the inner border of the sterno-cleido-mastoid muscle, or one of the poles may be in the hand of the patient. These methods are best adapted for the purposes of producing a sedative or tonic effect on the inflamed and irritated membranes. We have frequently used this treatment, for about five minutes after the application to the larynx of irritating caustics, with satisfactory results.† There is no question that the faradic current, employed perseveringly by these methods, and in cases of anæmia and general debility, by general electrization, will alone accomplish something in anæmia, subacute inflammations, and nervous debility of larynx.

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* See Tobold's Chronic Diseases of the Larynx, translated by Dr. Beard. 1868, p. 166.

† See introduction to Translation of Tobold, pp. 63–70.

APHONIA.

There are few local disorders that yield more uniformly or readily to any method of treatment than aphonia to electrization. In order, however, to form a correct idea of its value in these cases, or to intelligently communicate the results of electrical treatment, it is necessary to have not only a knowledge of the general nature of the disease, but to appreciate, so far as possible, the exact pathological condition of each individual case. Above all, it is necessary to decide whether the symptom is of an organic or of the so-called functional character. Mackenzie, who has had an extended experience in nervous affections of the larynx, and their treatment by electrization and otherwise, adopts the following nomenclature of the paralysis of the muscles acting on the vocal cords: *

1. Bilateral paralysis of the adductors.
2. Unilateral paralysis of the adductors.
3. Bilateral paralysis of the abductors.
4. Unilateral paralysis of an abductor.
5. Paralysis of the tensors.
6. Paralysis of the laxors.

The *first* of the above-mentioned pathological conditions of aphonia is supposed to depend most frequently upon hysteria and debility, and readily yields to treatment. In these cases, however, which are too frequently but the local manifestation of a constitutional disorder, it has been our custom to rely on general as well as localized electrization.

Central difficulty is rarely a cause of bilateral paralysis of the adductors, but it is not uncommon in certain stages of phthisis. In 37 cases of phthisis, examined by Mackenzie, in which the voice was affected, he found that in 26 there was thickening or congestion of the mucous membrane of the larynx, while in 11 the affection was purely functional. Aphonia, then, coexisting with pulmonary tuberculosis, may often be readily relieved by local treatment alone.

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* On the Laryngoscope, &c., p. 183. Also Hoarseness, Loss of Voice, and Stridulous Breathing, in Relation to Nervo-muscular Affections of the Larynx. 1868.

Hysteria and debility are not so frequently the cause of unilateral paralysis of the adductors as of the first-named condition. This second cause of aphonia, however, may be due not only to phthisis, but to toxæmic poisoning, to syphilis, to cold, to muscular strain, and even to cerebral disease. We would naturally infer that this form of aphonia would be more persistent than the first-named.

Clinical experience has confirmed this inference.

Bilateral paralysis of the abductors of the vocal cords has, unfortunately for its causation, in the majority of cases, some central difficulty.

The prognosis is of course most serious, but fortunately this condition is very rarely met with. Unilateral paralysis of an abductor, although depending on the same general cause as the bilateral form, yet, more frequently than the last-named, it is excited by some peripheral irritation, as pressure on the pneumogastric nerve, or upon one recurrent nerve, by an aneurism of the arch of the aorta. The prognosis in these cases is also unfavorable.

Paralysis of the tensors and laxors (both the bilateral and unilateral form) are supposed to result, in the majority of cases, from a too prolonged or violent use of the voice. Both are said to be quite amenable to treatment.

Laryngoscopic examination reveals the following conditions of the vocal cords in the above-mentioned forms of paralysis.

1st. *Bilateral paralysis of the adductors.*—Here, when the patient attempts to say "a," "e," or "o," the cords do not approximate, although they may approach each other somewhat.

2d. *Unilateral paralysis of the adductors.*—In attempting to speak, the vocal cord affected remains at the side of the larynx, while the other one is seen to move as usual towards the median line. The mucous membrane of the cord is frequently congested, and if cerebral difficulty exists, some of the surrounding parts, as the tongue or palate, may be paralyzed.

3d. *Bilateral paralysis of the abductors.*—In this discouraging condition the cords approximate so that the aperture between them is very slight indeed. In forced inspiration they sometimes approximate completely, while in forced expiration they recede a little from the median line.

4th. *Unilateral paralysis of the abductors.*—During inspiration the vocal cord affected is not drawn aside, while the other recedes as usual from the median line.

In both forms of paralysis of the abductors tracheotomy is to be performed when the symptoms become so serious as to endanger life.

5th. *Paralysis of the tensors.*—During phonation the vocal cords are not sufficiently stretched. It can be seen that the surface of the vocal cords are not perfectly horizontal, and the processus vocalis cannot be seen. The cords also are by no means drawn so completely aside as in the healthy state.

6th. *Paralysis of the laxors.*—The cords are seen to be unusually tense, and generally slightly congested.

Spasm of the muscles controlling the vocal cords is an additional cause of aphonia.

Our experience in the treatment of the disease under consideration has been quite limited. The few cases, however, that have fallen under our care seem to confirm the admirable results by Mackenzie and a few others.

Treatment.—Mackenzie's method is to make the application directly to the cords by means of laryngeal electrodes (p.530) devised by him.

He uses the faradic current.

The direct application of electricity to the vocal cords is undoubtedly more efficacious in restoring loss of voice than simple external application. This latter method is, however, underrated when it is said that it "*seldom* restores the voice when it has been lost any length of time."

Several cases that we have treated at various times illustrate very decidedly the beneficial results that may follow external applications, even in cases where the disorder has persisted several months. We are the more gratified to be able to make this statement from the fact that the external is much more readily performed by the operator than the internal application, and is far more agreeable to the patient. It is far better at first, in all ordinary cases, to make use of the external method; and if it does not succeed, it is time enough to resort to the direct application. The instrument of Mackenzie is thus described in his own words:—

"It consists of two parts, viz., the necklet which the patient wears, and to which one chain of the battery is attached, and the laryngeal electrode itself, which is connected with the other conductor. The electrode is so constructed (see cut) that the current does not pass beyond a certain point until the pole is seen, in the laryngeal mirror, to be upon the vocal cords, when the operator touches a little spring in the handle, and the current immediately passes through the laryngeal muscles. The necklet should be worn rather low, so that it covers the sides of the cricoid cartilage, and the space between it and the thyroid. In this way the lateral adductors of the cords (crico-arytenoidei laterales) can be most easily reached; and the arytenoideus proprius, or central adductor, may be electrified by placing the pole on the posterior surface of the arytenoid cartilages.

"I generally keep the pole in the larynx for three or four seconds each time it is introduced, and pass a succession of short rapid shocks through the larynx; and at each sitting I apply the pole to the interior of the larynx three or four times."

Mackenzie is of the opinion that the effects are of a *reflex* as well as direct character.

Meyer* reports successful results in the treatment especially of hysterical aphonia by the electric moxa, applied to the larynx.

Some of his cases were cured by a single application, in others a course of treatment was required. Tobold speaks favorably of the electric moxa in hysterical aphonia. It should be borne in mind that in hysterical aphonia any form of irritation, external or internal, electrical or otherwise, may cause instantaneous cure. Some of the most brilliant achievements of mesmerizers and of those who practise laying on of hands and other flummeries, have been made in hysterical aphonia.

Kind of current to be employed.—For electrization of the larynx, externally and internally, both currents have been used with success. Mackenzie used chiefly the faradic current of a magneto-electric (rotary) machine, for the reason that he had no magneto-electric apparatus that was always reliable. He has obtained good results with both forms of faradic apparatus.

On the comparative value of the galvanic and faradic currents in the treatment of aphonia, Tobold† thus remarks :—

"Although I have frequently demonstrated the good results of the induced (faradic) current in many cases of paralysis, yet I cannot deny that its working is sometimes very protracted or utterly inefficacious. I have, therefore, for a longer time used the constant (galvanic) current in the various forms of paralysis of the glottis, and can truly say that its effect, especially in *phonic* paralysis, is often speedy, and that it often produces comparatively quick results, when the induced (faradic) current is unsatisfactory or negative."

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* Op. cit., p. 436 et seq.

† Op. cit., p. 190.

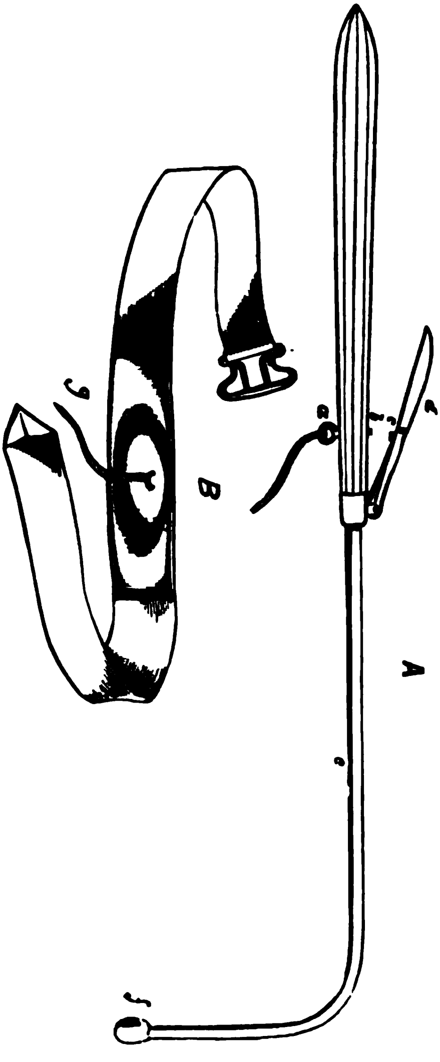

FIG. 84.—LARYNGEAL ELECTRODE AND NECKLET.

A represents the electrode (No. 1). The instrument is connected with the electric apparatus by the connecting wire at *a*. When the insulated handle is pressed upon, the circuit is closed by the junction of *c* and *b*, and the current passes to the metallic point *f*. The wire *e* and the handle of the electrode are insulated. *B* is the necklet.

Mackenzie has also devised another form (No. 2) of electrode, in which the two poles are united in the same instrument, after the manner of Duchenne's *double vesical electrode*.

Dr. Louis Elsberg of this city states that he has used both currents at the same time (localized galvano-faradization) in the treatment of aphonia.*

IRRITATION OF THE MUSCLES OF THE LARYNX.†

Crico-thyroid.—This muscle may be caused to contract by applying pointed electrodes by the conoidal ligament. The effect of the contraction is to cause the annular and thyroid cartilages to approach each other.

Arytenoid Transverse, at the posterior surface of the arytenoid cartilages. The effect of the contraction of the muscles is to cause the cartilages to approach each other.

Crico-arytenoid and Thyro-arytenoid muscles, in the sinus pyriformis, between the posterior border of the thyroid cartilages and the plate or surface of the cricoid cartilages.

Crico-arytenoid Posterior (dilator of the glottis), downward and backward from the sinus pyriformis.

Crico-arytenoid lateralis, in the sinus pyriformis on the exterior border of the surface of the annular cartilage. Contraction of these muscles produces rotation of the cartilages of the larynx, with movement of the vocal cord toward the median line.

Thyro-arytenoid, beneath the anterior superior border of the crico-arytenoideus lateralis. Contraction of this muscle brings the cartilages of the larynx forward and downward, and narrows the glottis.

Thyro-epiglottic and ary-epiglottic muscles, at the border of the epiglottis.

Prognosis in Aphonia.—The prognosis in aphonia depends entirely on the pathology. In *functional* (bilateral paralysis of the adductors) aphonia the prognosis is more favorable than in almost any other disease that is known to science. The majority of cases will recover, whether external or internal applications are used, although Mackenzie contends that the recovery is much surer and speedier when only external applications are used. He says out of more than *two hundred* such cases he has succeeded in all except four. In some of these cases the aphonia was of six, seven, and eight years' standing.

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* Physician and Pharmaceutist, vol. i. No. 1.

† The subject of direct electrization of the laryngeal muscles has been studied by Ziemssen. Elektricität in der Medicin, 1866.

In *unilateral paralysis of the adductors* the prognosis is good when the origin is local and bad when it is central.

In bilateral paralysis of the abductors and *unilateral paralysis of the abductor* the prognosis is unfavorable.

In *paralysis of the tensors of the vocal cord* the prognosis is usually favorable.

In *paralysis of the laxors of the vocal cord* the prognosis is on the whole favorable, but much time is required.

Our friend, Dr. F. I. Knight, of Boston, who has given this subject special attention, writes us as follows :—

> "In cases of functional aphonia arising from bilateral paralysis of the muscles closing the glottis, and regulating the tension of the cords, the application of the electric current (one pole being placed within the larynx) almost never fails to effect a cure sooner or later. In many cases it seems to be of no consequence what current is used, a speedy and sometimes immediate cure being effected through reflex action. There are other cases, however, coming under this general class, in which the muscles seem to have become weakened, and in which normal action is restored only after prolonged treatment. In

party of young friends on one of our rivers. She had for some time previously complained of slight irritation of throat, but it caused but little annoyance. The evening was somewhat damp, and the patient carelessly uncovered her head during the whole time the party remained in the boat. While singing, and endeavoring to strike a very high note, she felt as if something in her throat had "relaxed or suddenly given way." For one week she remained so completely aphonic that she could not utter an intelligent word. In the course of another week, however, she could speak at times so as to be understood, but only with considerable difficulty, and not above a *very* feeble whisper. At this point all improvement ceased, and no form of medication, or external or internal application, seemed to be of any benefit whatever. Laryngoscopic examination revealed the following condition of the parts affected. On attempting to speak the right vocal cord remained almost if not quite motionless, while its fellow approached the median line. It was evident from the feeble and imperfect working of the left cord that it also was considerably involved and doubtless had been completely paralyzed. The surrounding tissues were considerably congested.

The negative electrode was placed upon the spine, between the shoulder-blades, and, using our fingers as electrodes, we passed a steady current through the neck for about ten minutes. At the conclusion of the séance the patient could speak in quite a loud whisper, and a second examination with the laryngoscope revealed the fact that the right vocal cord perceptibly approached the median line during the act of phonation. The voice of the patient gained strength rapidly, until in four days, and after receiving but two similar applications, she was able to speak as loud and sing as vigorously as ever.

The following cases we transcribe from Mackenzie's work :—

"*Loss of voice of eighteen months' duration, from paralysis of the adductors, cured by one application of electricity to the vocal cords.*

"Louisa C., a servant, aged 23, from Newbury, was admitted into the Hospital for Diseases of the Throat, July 4th, 1867. Though stout, she was rather weak, and fainted on her first visit to the Hospital. For this reason she was received as an in-patient. She stated that her loss of voice was a serious drawback to her, and that it prevented her getting a situation.

"It was seen that the vocal cords scarcely moved at all towards the median line on attempted phonation. One application of electricity restored the voice, and after remaining in the Hospital two or three weeks, to get her strength up, she was discharged 'cured.'"

"*Aphonia of three years' duration, from paralysis of the adductors, cured by the direct application of electricity to the vocal cords.*

"Fanny S., aged 20, was admitted into the Hospital for Diseases of the Throat, July 14th, 1867, on account of loss of voice of three years' duration. Eight months previously she had applied at the Hospital, and her voice had been restored on several occasions by the direct application of electricity; but the effect had always been very transient, the voice having generally been lost again after a few days. At that time she lived at some distance from the Hospital, and could not visit it very often, and for the same reason it was necessary now to make her an in-patient. The laryngoscope showed that the case was one of paralysis of the adductors of the vocal cords. After three applications of electricity to the vocal cords, the voice was fully restored, and since July 20th the voice has remained strong."

"*Dysphonia of fourteen months' standing, from paralysis of the adductors of left vocal cord, after diphtheria, cured by electrization of the vocal cords.*

"Patrick O——, aged 19, was sent to me in April, 1863, but I first commenced treatment in the middle of May. The patient stated that in March, 1861, he had an attack of diphtheria; that since that time he had always found great difficulty in speaking aloud, and that when he did succeed, his voice was always 'very squeaky.' On looking into the throat, the pillars of the fauces presented a peculiarly atrophied appearance, and on the posterior wall of the pharynx there were several lumps of inspissated mucus. On using the laryngoscope, and directing the patient to say 'Eh,' it was seen that, whilst the right vocal cord advanced well to the centre, the left vibrated slowly, without moving at all towards its fellow. The sound produced was in the falsetto register, and he was unable by the most violent efforts to produce a chest-note. He stated that before he suffered from diphtheria he had a remarkably loud and strong voice.

"On the application of electricity to the cords, he at once spoke in the chest-register. The high-pitched squeaking voice soon returned, however—according to the patient's account, 'directly he got into the open air.' Electric shocks were continued, first every day, and afterwards every two or three days, for two months, when, the voice having been restored for more than a fortnight, and the left vocal cord acting perfectly, it was not thought necessary to continue the treatment." [No general remedies were employed in this case.]

"*Dysphonia of a year's duration, from paralysis of the laxors of the right vocal cord, cured by electricity.*

"Madame C——, aged 34, a professional singer, consulted me in May, 1865, on account of a difficulty she had experienced during the last year in forming her lower notes. Her voice in the ordinary way extended from *d* above the line to *a* below. A year ago she first experienced slight difficulty in forming the lower *a*, and in January she could not reach beyond *b*. During the last two months she had not been able to sing at all, even in private. She broke down directly she attempted even a few notes. She attributed the loss of power to a strain, as she first noticed the difficulty after the performance of a long and trying cantata, which had been twice encored. At the time she had experienced 'a stinging sensation, extending from the right side of the throat up towards the ear.'

"She had been constantly under treatment since her voice first became affected. 'The only thing which had seemed to do her good was a solution of caustic applied to the throat with a piece of sponge at the end of a whalebone rod.' But though this treatment always gave temporary relief, there was no permanent improvement. On making a laryngoscopic examination, the parallelism between the vocal cords was seen to be lost, the right cord curving away in the centre from the median line.

"The treatment (direct electrization of the right vocal cord) was long and tedious in this case. At the end of six weeks there did not appear to be any improvement, and I should have given it up had not the patient most earnestly begged of me to continue a little longer. I was glad that I did so, for a fortnight later the patient perceived a marked improvement in the voice. In order to test the voice I used to allow the patient to sing a few notes once a week, but at no other time. At the end of three months the voice was decidedly improved, and the following autumn the voice was so completely restored that the lady was able to accept an engagement in Madrid."

SPASMUS GLOTTIDIS (LARYNGISMUS STRIDULUS—SPASM OF THE GLOTTIS).

In this affection, which is acknowledged to be of a nervous character, electrical treatment is indicated on the same principles on which it is indicated in *torticollis*, *writer's cramp*, and *facial spasm*.

The disease is caused by any influences that depress the system. In children it may arise by reflex action from the irritation of teething or of worms ; in adults it is often an accompaniment of hysteria, and arises from diseases of the sexual organs.

Treatment.—General faradization and galvanization of the sympathetic, and external galvanization and faradization of the larynx by any of the methods described on pp. 523 and 528.

Tobold * reports success with peripheral and central galvanization in this disease. A strong maiden, 23 years of age, who was attacked regularly every night with severe spasms of the larynx, was entirely cured in four weeks by galvanization.

HYPERÆSTHESIA OF THE LARYNX.

Cases of this disease have been reported by Gerhardt and Hanfield Jones. It may be either constant or intermittent.

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* Op. cit., pp. 176, 177.]

ANÆSTHESIA OF THE LARYNX.

This is an affection but rarely observed. It would be most likely to occur from injury of the pneumogastric nerves or of their laryngeal branches.

It is rational to suppose that both hyperæsthesia and anæsthesia of the larynx might be successfully treated by electrization in its various forms, on the same principles that these morbid conditions are treated in other parts of the body.

MUTEISM.

Muteism of 28 *months' standing, in a boy of* 17—*Recovery under electrization.*

CASE 142.—M. Jubiot* reports a case of muteism in a boy 17 years of age. He woke up one morning entirely deprived of speech. His health previously had been good, but from that time he lost his vivacity and became almost idiotic, and was accustomed to run out his tongue. After four months there was return of intelligence. M. Jubiot suspected nocturnal convulsions,* and one electrode connected with an electric current (whether faradic or galvanic is not stated) was applied to the nape of the neck, and the other to the lateral and anterior regions of the neck, or by the two external auditory canals. Before treatment he had made no sound. The second day after treatment a confused sound appeared. After the tenth application he cried loudly. At last he said, "*Good day, Monsieur, I am well; I am cured!*"

**Marseilles Medicale*, Janvier, 1870.

CHAPTER XXXII.

DISEASES OF THE EYE.

For two reasons the diseases of the eye are not as amenable to electrization as corresponding or analogous diseases in some other parts of the body.

First, Its anatomical position is such that the current cannot be directly localized in some of its parts; and *secondly*, the application of a very strong current is frequently contra-indicated by the sensitiveness of the conjunctiva, and the possible injury that may be done to the brain.

For these reasons paresis and paralysis of the muscles of the eye—the conditions of the organ that are most frequently treated by electricity—cannot be as successfully subjected to electro-diagnosis or therapeutics as the same conditions of many other muscles, although therapeutic results that in many instances are of a decided character are obtained from electrization of the paretic or paralyzed muscles.

The diseases of the eye for which electricity has been employed with more or less success are *paralysis of the muscles*, *asthenopia*, *retinal hyperæsthesia*, *amaurosis and amblyopia*, *spasm of the lid*, *ptosis*, *opacities of the cornea*, *photophobia*, *myosis and mydriasis*, *and neuro-retinitis.*

Electrization of the Eye.—The electric current affects the eye both directly and through reflex action from the fifth pair, and also through the sympathetic. As has been stated, the anatomical position of the eye within its bony cavity makes it impossible to reach all its parts as directly as could be desired, while the exceeding delicacy of its structure makes it at least very difficult to make the applications immediately to the conjunctiva.

The eye may be electrized in a general way, in asthenopia, for example, by pressing one large positive electrode over the closed eye, and the other at the occiput or by the side of the head above the mastoid bone, or one of the electrodes may be held in the hand. When it is desired to produce chemical changes in the eye this stabile method of application may be used for some time. Placing the positive pole on the forehead or in the auriculo-maxillary fossa, the *superior oblique* may be excited with the negative pole on the upper and inner part of the orbit; the *inferior oblique* and *rectus internus* near the inner angle of the eye on the side of the nose; the *rectus externus* at the outer angle of the eye; the *rectus superior* at the upper part, and the *rectus inferior* at the lower part of the eyeball. Galvanization of the eye with interrupted currents to affect the muscles should usually be short, but stabile or labile faradization with large electrodes may sometimes be made for a much longer time—three to ten minutes.

Paresis (*relaxation*) or *paralysis* of the muscles of the eye may arise from cerebral lesions, or may be of a peripheral character. Locomotor ataxy is frequently preceded or accompanied by disorders of the muscles of the eye.

For the purpose of affecting the muscles of the eye the galvanic current is usually superior to the faradic. A small number of cells, from 10 to 15, are usually sufficient. Galvanization of the sympathetic should also be tried in those cases that are supposed to be of cerebral origin. Short treatments, from one-quarter of a minute to one or two minutes, are preferable to longer applications. In these conditions protracted séances not unfrequently do injury.

Here, as elsewhere, the sensitiveness of the patient and the results in each case are perhaps the best guide. And yet it is always well to be cautious in the first application. In diseases of the eye, as of other parts of the body, we meet with exceptional cases that will bear and be benefited by very protracted applications of mild galvanic currents.

The unfortunate accident that happened to Duchenne—total destruction of the sight of a patient immediately after galvanization—did much for a time to retard the electro-therapeutics of the eye. The accident, however, has never been repeated, although the electro-therapeutists of the present day galvanize the eye and the brain with great freedom.

Localized *faradization* has been somewhat successful in the treatment of paralysis of the muscles of the eye in the hands of Meyer,[*] Soelberg Wells,[†] and Althaus.[‡] Althaus has succeeded with the faradic current after failure with the galvanic.

Prognosis in paralysis of the muscles of the eye.—The prognosis of paralysis of the eye that depends on cerebral lesions is usually unfavorable. Cases that arise in the early stages of disease of the brain or spinal cord, as locomotor ataxy, offer a good prognosis, though they are disposed to relapse.

Peripheral cases, when taken in the early stages, have a very favorable prognosis, but not so with cases that are long standing.

Benedikt, speaking of the prognosis in cases of paralysis of the eye, declares that of eight cases, from various causes, that were sent to him by Wecker of Paris, in seven there was immediate improvement.[§] The same writer states that when the absolute excursive capacity of the pupil is little altered, but double vision is present in a great part of the visual field, the prognosis is unfavorable.

In some cases improvement follows early, after one or two sittings, or during the midst of the sitting; in other cases not until ten or fifteen.

The tendency with patients and physicians is to abandon treatment in paralysis without giving it a fair trial. They certainly demand as long, and, if we are to argue from the anatomical difficulties in the way, even longer treatment than analogous affections in other parts of the body.

The following are some of Benedikt's[‖] cases :—

"*Paralysis of the abducens.*—Stadler, Johannes, aged 29, laborer (Arlt's clinique, Feb. 16, 1864), had suffered for three weeks from mild paralysis of the right external rectus, without any known cause; there was double vision of a high grade. After four séances the excursion was normal, and in three weeks he was entirely cured.

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[*] Op. cit., p. 378.

[†] Diseases of the Eye. 1869. p. 568.

[‡] Op. cit., p. 495.

[§] Op. cit., p. 292.

[‖] Op. cit., p. 297 et seq.

"Burggraf, Johann, aged 23 (Arlt's clinique, April 22d, 1864), had been suddenly seized with double vision 14 days previously. Paralysis of the right abducens, preceded by violent pains in the head for eight days. Recovery through local treatment in six sittings.

"Meyer, Antonia, aged 55, laborer (Arlt's clinique, Sept. 18, 1866), had suffered for three days from double vision, paresis of the right abducens. The excursion was deficient by one line. There was double vision in the larger half of the visual field. After nine sittings the excursion was normal. Double vision in the extreme portion of the visual field. Entire recovery after 20 stittings.

"Mako, Barbara, aged 24 (Arlt's clinique, Jan. 29, 1863), suffered for six weeks from complete paralysis of all the branches of the oculo-motorius. After three weeks the paralysis was removed, and the patient, although he had yet some double vision, left the hospital.

"*Isolated mydriasis.*—Rentier, aged 40, suffered from mydriasis and paralysis of accommodation on the left side. After two local treatments the mydriasis diminished. It relapsed after a coitus, but was finally entirely healed in 12 sittings, and remained healed for several years."

The following is a sample of the less favorable results :—

"*Combined paralysis.*—Pistory, Josef Schneider, aged 37 (Arlt's clinique, Feb. 7, 1863), suffered for many years from vertigo. For two years, according to his own account, there had been paralysis of both *recti superiores*, especially marked on the right side. After two months' local treatment he left not essentially improved.

"Schidloff, Betti, aged 68 (Arlt's clinique, Oct. 14, 1864), suffered without known cause for six weeks from complete paralysis of the abducens with contractions of the antagonists. After eight days left wholly unimproved.

"*Paralysis in the region of the oculo-motorius.*—Grolms, Josef, aged 49 (Arlt's clinique, May 18, 1866), suffered for eight days from incomplete paralysis in the region of the right oculo-motorius (ptosis and paresis of the internal rectus). He was galvanized and faradized three months without essential results.

"*Paralysis of the Trochlear.*—Kaffeebaum, Osias, aged 50 years (Arlt's clinique, June 19, 1864), exceedingly nervous, had suffered for four weeks from paralysis of the trochlear muscle of the left side, and for some days there had been twinges in the ear. He was treated a short time without essential result."

Asthenopia.—Asthenopia may depend on an absolute or relative deficiency of energy in the muscle of accommodation ; or of the internal recti. It is accompanied by hyperæsthesia of the retina and ciliary nerves.* Of these two forms, the accommodative and muscular, the accommodative is the more frequent. The marked effects in improving the tone of exhausted muscles in other parts of the body, produced by electrization, would lead us to suppose that asthenopia might be benefited by passing either the faradic or galvanic current through the eye.

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* Stellwag, Treatise on the Diseases of the Eye, translated by Drs. Hackley and Roosa, p. 622.

In quite a number of cases of weakness of eye with hyperæsthesia, that have not been accurately recorded, we have obtained positive and rapid results. For those very numerous cases of eyes that ache severely if used even for a little time before breakfast, or at twilight, or in reading fine print, or doing fine needle-work, or from exposure to glaring light; that perhaps are annoyed by *muscæ volitantes* and by neuralgic pains in or near the eye, and yet in which ophthalmoscopic examination reveals no lesion—for such cases mild labile faradization for five or ten minutes through the eye with the positive pole, either with a moistened sponge or the hand of the operator, while the negative is at the back of the neck or in the hand of the patient, is certainly a most agreeable and efficacious remedy. Stable galvanization is also useful in the same condition. Cases of this kind that are associated with general feebleness, with hysteria, and dyspepsia, are sometimes much benefited by general faradization even when the eye receives no local treatment whatever. The *tired, aching eye* is both temporarily rested and relieved after each sitting, and permanently strengthened by continued treatment. In such cases electrization does for the eye what it does for the stomach, or larynx, when they are in a condition of fatigue.

We believe that electro-therapeutics promises more for asthenopia, with hyperæsthesia of the retina, than for any other disease of the eye.

We therefore must regret that the cases of weakness, exhaustion, and neuralgia of the eye which we have successfully treated by faradization were not submitted to ophthalmoscopic examination at the hands of acknowledged specialists. Most of these cases were under our care for other affections, and the eyes were treated only incidentally.

From the known effects of electrization on neuralgic and muscular weakness of other parts of the body, it would certainly appear that asthenopia, even in its severe phases, might also be successfully treated by the same agent.

The subject is worthy of the earnest attention of ophthalmologists.

Amblyopia and Amaurosis.—Amblyopia is now understood to be a disorder of vision dependent on disturbance of the circulation, while amaurosis is to be regarded as a symptom of atrophy of the optic nerve.

For some of these conditions electrization may be tried with advantage.

A strong encouragement for a faithful trial of electricity in these cases is that various degrees of impairment of vision, from complete blindness through the lower grades, upon no reliable diagnosis of the pathological condition, have been sometimes most successfully treated by physicians and charlatans, with diverse methods of application. De Saussure cured a case of amaurosis by statical electricity. Lesueur, Magendie, and Person successfully used faradization in the same cases.

Successful results have occasionally been obtained by the laity.

What is now needed is a careful and persevering trial of galvanization and faradization in cases of amblyopia and amaurosis, after accurate ophthalmoscopic examination.

Spasm of the Lid.—For spasm of the *levator palpebræ* and *orbicularis palpebrarum*, faradization or galvanization is indicated for the same reason that it is indicated in torticollis, facial spasm, and spasm of the glottis.

The method of application is the same as that prescribed for asthenopia.

Prognosis.—Recent and mild cases recover rapidly. Long-standing cases are sometimes very obstinate, but even these are frequently relieved for a limited time after each sitting.

Slight spasmodic twitchings of the lid—Recovery under faradization.

CASE 143.—A lady had been troubled with an affection of the left eye that required surgical treatment; was taken with slight but disagreeable twitchings of the lid of the other eye. The twitching was so slight that it could be seen by an observer only with difficulty.

Under faradization with a mild current, the negative pole being held in the hand of the patient, and the positive being applied by gentle passes over the lid, recovery took place in a short time.

Spasm of the orbicularis palpebrarum of long standing—Some temporary but no permanent benefit from faradization and galvanization.

Case 144.—Rev. Mr. B. was referred to us by Dr. C. R. Agnew with severe spasms of the orbicularis palpebrarum of the right side; the general health of the patient was otherwise good. Faradization and galvanization, faithfully used for a number of sittings, in the manner described in the case preceding, were only of temporary benefit.

Opacities of the cornea.—The electric currents have been employed with more or less success for opacities of the cornea for many years. Cases have been reported by Isiglio, Quadri, Willebrand, Türck and Graefe.

Recently this method has been but little employed.

The galvanic current would be more indicated than the faradic. External or internal applications may be used.

Photophobia.—Photophobia is a symptom of so many different pathological conditions, that the cases of cure or relief obtained in it by the electric currents are of comparatively little value. It very frequently depends on the diseases of the conjunctiva and cornea. Hewson reports the cure by galvanization of 32 cases of photophobia dependent on scrofulous inflammation of the cornea in children. From one to three applications were sufficient.

The positive pole was applied to the face and the negative to the supra-orbital foramen.

Ptosis.—This affection, which consists in paralysis of the elevator of the upper lid, is to be treated like spasm of the lid, but with a stronger current. The galvanic current may, in some cases, be more serviceable than the faradic, although we are not aware that there are yet any clinical evidences of this belief.

Mydriasis and Myosis.—In these conditions the electric treatment may sometimes be of value, although in the majority of cases it depends on some central difficulty that in its very nature is incurable.

The *treatment* consists in placing the negative pole over the closed lid and in galvanizing the sympathetic. (For an interesting case of mydriasis with complications, see p. 413.)

The following are samples of Benedikt's* cases:—

"Adam, Joseph, aged 23 (Arlt's clinique, June 13, 1864), suffered for a long time from twinges in his sleep. For two months there had been mydriasis of the left side. There was reaction of the pupils to light and in accommodation. With the diseased eye he read Jäger No. 7; after 16 days' treatment he read Jäger No. 2, and lively reaction to light and in accommodation; the pupils are sometimes alike. There was no further progress. He was subsequently treated by faradization and galvanization of the sympathetic without further result. The patient indulged excessively in venery."

"Fiala, George, lieutenant of artillery, aged 30 years (Arlt's clinique, July 4, 1865), had periodic pains in the head, and remarked two years before sudden narrowing of the pupils and myosis on the right side. Local treatment and galvanization of the sympathetic were employed. After a number of weeks the patient left improved."

Neuro-retinitis.—On the theory that neuro-retinitis may depend on some morbid condition of the sympathetic, which in its turn may be connected with various cerebral affections,† it has been treated by galvanization of the sympathetic, and of the brain. (See p. 174.)

Indeed, from our experiments in galvanization of the sympathetic (see p. 276), it would appear that in neuro-retinitis, and, indeed, in all affections where we wish to affect the vascular condition of the retina, galvanization of the sympathetic would very properly be indicated in connection with other remedies directed to the disease. The subject is certainly worthy of investigation.

Strabismus.—In strabismus, dependent on merely transitory causes, faradization or galvanization may be of service; but the results yet reported are not of great importance.

That temporary relief of strabismus may be derived from faradization we demonstrated in several instances. The method of application is the same as that for paralysis of the muscles.

Among other diseases of the eye in which electrization may be tried experimentally with the hope of greater or less success, are *anæsthesia optica*, and *nystagmus*.

Cataract.—The attempt to dissolve cataract by galvano-puncture has been made by Crussel, with the result of inflammation and destruction of the eyeball.

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* Op. cit., p. 303.

† Benedikt, op. cit., pp. 252, 253, 254.

It is stated, however, by Graefe,[*] that applications of the negative pole of a galvanic current have been successful.

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[*] Deutsche Klinik, 1852, p. 445, quoted by Althaus.

CHAPTER XXXIII.

DISEASES OF THE EAR.

THE diseases of the ear, as of the eye, are less amenable to treatment by electricity than analogous diseases in most other parts of the body, and for the same reasons. By its anatomical position the internal ear is even more inaccessible than the eye; and even the parts which can be brought more directly under the influence of electrization, as the middle ear, the membrana tympani, and external auditory canal, can bear only feeble currents and short applications. These parts are, indeed, more sensitive than the eye, but even were they capable of bearing stronger currents, their nearness to the brain would render it necessary to exercise caution, especially when using the galvanic current.

The morbid conditions of the ear for which electrization has been found of service are subacute and chronic ***inflammation of the drum and middle ear***, ***nervous deafness***, and ***tinnitus aurium***.

Experiments on the ear were made quite early in the history of electro-therapeutics.

Brenner[*] gives the following bibliography of this department in the early part of the present century :—

AUGUSTIN—*Versuch einer Geschichte der galvanischen Elektricität und ihrer medicinischen Anwendung*, Berlin, 1801 (this work contains a quantitative distinction in the working of both poles on the nerves of hearing); also, *Vom Galvanismus und dessen Anwendung*, 1801, by the same author.—MERZDORFF—(*Behandlung des Ohrensausens durch den Galvanischen Strom,*) *bei* GRAPENGRESSER, 1801, pp. 131 and 132.—FLIES—(*Galvano-therapeutische Versuche,*) Ebendas., 1801, pp. 241, 252.—STELLWAG—*Ueber Galvanismus*, Hamburg, 1802 (this work contains cures of deafness).—STRUWE—*System der Medicinischen Elektricität mit Rücksicht auf den Galvanismus*, 1802.—

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[*] Untersuchungen und Beobachtungen auf dem Gebiete der Electrotherapie, 1 Band, 1 Abth., 1868, p. 40.

WOLKE—*Nachricht von den zu Jever durch die Galvani-Voltaische Gehörgebekunst beglückten Taubstummen*, etc. Osnabrück, 1802.—MARTENS' *Therapeutische Anwendung des Galvanismus.* 1803.

It was natural that attempts to cure diseases of the ear should be made thus early in the history of electro-therapeutics, because at that time there was scarcely any other method of treatment.

There are two general methods of electrizing the ear—*internal* and *external.*

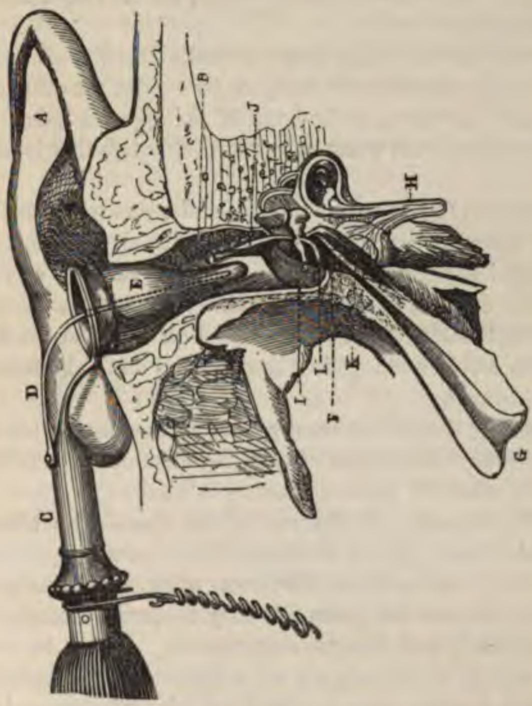

FIG. 85.—*Internal method of electrization of the ear* (Duchenne). A, auricle; B, external auditory canal; C, handle of electrode; D, flexible wire; E, rubber speculum; F, ossicula in middle ear; G, mouth of tube; H, auditory nerve in inner ear; I, inferior half membrana tympani; J, external muscle of hammer; K, internal muscle of hammer.

The flexible wire can be pressed in toward the drum and then allowed to spring back. The external auditory canal is very sensitive, and only mild currents or currents quickly interrupted will be borne. The other electrode may be placed in the hand of the opposite side, or at the mouth of the Eustachian tube, by means of a metallic-pointed insulated catheter. It is an advantage before making the application to partly fill or at least to moisten the ear with warm salt water, since thereby the conduction is much increased. The water should be warm, because cold water is not well borne in the ear.

External method.—The best external method of electrizing the ear is to *press the electrode firmly on the tragus*, the other electrode being held as before, in the hand of the opposite side. The ear should be filled with warm salt water, although this is not necessary.

We have used this method for several years with both the faradic and galvanic currents, and prefer it for all cases except when it is desired to act directly on the inflamed surfaces of the drum, or middle ear. It is far less painful and more satisfactory than the internal method. It may be used on the most sensitive children, who would rebel against the internal method, however skilfully performed.

The sitting should not usually be more than five or ten minutes, and in some cases much shorter applications should be used, especially when the galvanic current is used.

Electro-diagnosis of Diseases of the Ear.—The pioneer and principal laborer in the department of electro-diagnosis of diseases of the ear is Rudolf Brenner, of St. Petersburg, who for a number of years has given this subject special attention, experimenting chiefly with the galvanic current. At first he shared the fate of nearly all the original experimenters in electro-therapeutics. His theories were rejected and his facts disputed both by aurists and electro-therapeutists.

Schwartze,* an aurist of high repute, claims that after having followed the experiments of Brenner step by step, he was forced to the conclusion that the statements of that author were radically erroneous.

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* Archiv für Ohrenheilkunde, i., p. 44.

Schulz,[*] of Vienna, a practised electro-therapeutist, has also denied the validity of the conclusions of Brenner.

Besides these, Sycyanko,[†] Bettelheim,[‡] and Schwanda,[§] of Vienna, have investigated the same subject, and have obtained only unsatisfactory or negative results.

Benedikt[‖] also contends that "normal nerves can react like those which are functionally diseased, or the reverse."

As a result of these unfavorable and hostile criticisms, the writings of Brenner for a long time were not received with favor, and were, indeed, generally scouted by the majority of aurists and electro-therapeutists.

On the other hand, Hagen[¶] has substantially confirmed the statements of Brenner, deriving his conclusions from the examination of fifty-two cases of diseases of the ear.[**] More recently Brenner has been reinforced by the powerful influence of Erb and Moos, of Heidelberg; the one accomplished as an electro-therapeutist, the other as an aurist.

Erb,[††] after experimenting on both healthy and diseased ears, states emphatically that "*those who deny the existence or the correctness of the matters of fact discovered by Brenner, are simply in error.*" Moos[‡‡] records a remarkable case of recovery of complete nervous deafness under the use of the galvanic current, in which nearly "all the assertions of Brenner were confirmed."

Still further, Brenner has published several and plausible replies to some of his opponents,[§§] in which he has pointed out the causes of their errors, which consisted chiefly in their imperfect appliances

[*] Wien. Med. Wochen., 73 and 77.

[†] Deutsch Archiv. Klinische Med., Bd. i., p. 601.

[‡] Wien. Med. Press, 1868, No. 23.

[§] Pogg. Annal.: 133, §§ 622–655.

[‖] Op. cit., i., p. 270.

[¶] Praktische Beiträge zur Ohrenheilkunde, Leipzig, 1866.

[**] Loc. cit., p. 7.

[††] Archives of Ophthalmology and Otology, vol. i., No 1, p. 232.

[‡‡] Archives of Ophthalmology and Otology, vol. i., No. 2, p. 464.

[§§] Op. cit., Bd. i., pp. 166, 167.

and faulty methods of experimenting. Schwartze, especially, whose influence has been most potent against him, he claims to have answered point for point.* To this Schwartze had not replied.

A careful examination of both sides of this important controversy has convinced us that the investigations of Brenner are, to say the least, worthy of the attentive consideration of all aurists and electro-therapeutists. We therefore present his leading conclusions. Those who desire to investigate the subject in greater detail are referred to the writings of Brenner, Hagen, Erb, and Moos above quoted.

The leading idea of the school of Brenner † is that ***the auditory nerve reacts to the galvanic current in a regular manner, by distinct sounds at and during the closing of the negative and at the opening of the positive pole, and that this reaction is variously changed by pathological conditions.***

These sounds are variously described as whistling, ringing, hissing, singing, humming, and rumbling. The sensation which is most frequent is that of *whistling.* In its typical uncomplicated manifestation, this whistling is a clear, independent, agreeable, musical tone. These sounds vary in different individuals and with the strength and continuance of the current.

The terminology and abbreviations employed by Brenner are as follows :—

RO.‡	—Right ear.	Kl.	—Ringing.
LO.	—Left ear.	Kl' or Kl''.	—Loud or very loud ringing.
Ka.	—Cathode (positive pole).		
Ka. S.	—Closing of the cathode.	kl.	—Weak ringing.
Ka. O.	—Duration of the closing of the cathode.	Pf.	—Whistling.
		Z.	—Hissing.

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* Loc. cit., p. 167.

† Zur Elektrophysiologie und Elektropathologie des Nervus acusticus. Petersburgh Med. Zeitschr., Bd. 4, p. 286. 1863. Also, Weitere Mittheilungen zur Elektro-otratrik. Petersburger Med. Zeitschr., Bd. 5, p. 35, 1863. And more recently in his published work, Untersuchungen und Beobachtungen auf dem Gebiete der Elektrotherapie. Leipzig, 1868 and 1869.

‡ These abbreviations correspond to German words.

Ka. O.—Opening of the cathode.
A. or An.—Anode.
AS. —Closing of the anode.
AD. —Duration of closing of the anode.
AO. or An. O.—Opening of the anode.

R. —Rumbling.
Si. —Singing.
Su. —Humming.
Br. —Roaring.
W. —Boiling of water.
Gl. —Ringing of a bell.
∞. —Continuous.
> —Gradually diminishing.

Roman numbers indicate the *number of the elements*, and *Arabic* the degrees of resistance of the rheostate. Thus XX 50 = 20 elements and 50 degrees of resistance.

The Rheostate.—The rheostate is an instrument by which the resistance of the circuit can be very gradually increased and diminished without breaking the circuit. The form that was originally devised by Wheatstone is made of two parallel cylinders; one of brass, the other of wood. On the latter is a spiral groove, in which a brass wire is coiled, about 40 yards long. This wire passes from the wooden to the brass, and is fixed on it. When the current enters the wire coiled on the wooden cylinder, it traverses the portion of the wire that is rolled on the cylinder, and which is insulated by the grooves in the wood, to the other cylinder, which is of brass, and therefore affords metallic conduction for the exit of the current. If the length of the current is to be increased, the cylinder should be turned by its handle from right to left, and *vice versâ* if the length of the current is to be diminished.*

The greater the length of wire through which the current passes, the weaker the current, and *vice versâ*. The rheostate has been chiefly used by the makers of telegraph instruments.

The rheostate has been introduced into electro-therapeutics by Brenner, who has used this instrument extensively in his investigations on the galvanic reaction of the auditory nerve.

The form of rheostate used by Brenner is represented in the accompanying cut.

The resistances are made by wires of different lengths interposed in the circuit. The form here represented allows of the interposition of any number of resistances between 10 and 2,100 by divisions of *tens*. Every desirable strength of current from one element to the full power of the battery can, by this arrangement, be subdivided into 210 *grades*. The sum of all the resistances is about equal to the taking off of an element of an average size.

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* Ganot's Physics, p. 790.

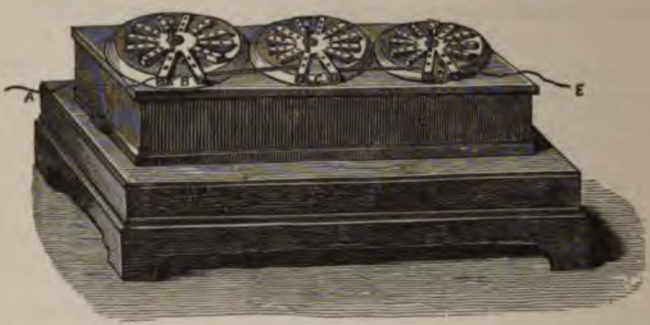

FIG. 86.—*Brenner's Stopper Rheostate.*—On the circle B, the metallic disks are numbered by units from 0 to 10; on the circle C, by tens, from 0 to 100; on the circle D, by hundreds, from 0 to 1,000. To use the rheostate, connect the wire A with one of the poles of the battery, and the wire E with one of the electrodes: in this way the resistances of the rheostate are included in the circuit, constituting what is called a "*secondary closure*." When all the stoppers are at 0 in all the circles there is no resistance. When all the stoppers are withdrawn there is no connection, and the current is interrupted.

Ten elements, for example, without the rheostate, are about equivalent to eleven elements with all the units of resistance of the rheostate included. The advantage of the instrument is obvious. It allows of the very gradual increase or lessening of the current within the limits of about the strength of an ordinary element, which is not possible by any other arrangement.

The term unit signifies a fractional portion of the resistance of the instrument, as determined by Siemen's standard, which is one metre of pure quicksilver of a constant diameter.

Brenner states that by the addition of a fourth coil of resistance, containing only units, the strength of the current may be subdivided into 2,100 grades.*

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* For a more detailed description of the rheostate the reader is referred to the first part of Brenner's work. 1868, pp. 51 et seq.

The average normal formula is thus represented:—

Ka.S.Kl.—Distinct sound.
Ka.D.Kl. —Sound gradually disappearing.
Ka.O. —No sound.
An.S. —" "
An.D. —" "
An.O.Kl. —Weak and short sound, similar to Ka.S.

The sensations with Ka.S. appear sooner and stronger than with An.O.

This formula, it will be observed harmonizes with the law of electrotonos (see p. 53), and Pflüger's contraction law—that "*a nerve is stimulated by the appearance of catalectrotonos and the disappearance of analectrotonos; not, however, by the disappearance of catalectrotonos and the appearance of analectrotonos.* (See p. 54).

Although the character of sounds vary with the strength and continuance of the current and with the individual, yet in the healthy ear the *polar effects* never vary.

There is never any sensation of sound with the closing of the anode (An.S.), except in pathological conditions.

The *polar effect* is therefore the leading effect, and the *direction* of the current through the auditory nerve appears to have no demonstrable influence.

The use of the rheostate and the changes in the reactions that are made by interposing the various grades of resistances in the circuit are represented in the following experiments of Brenner:*

The experiment was performed on a healthy ear that had been cured a short time before of a catarrh of the middle ear. The number of elements is in *Roman*, the number of resistances in *Arabic*.

XX 10- 80 gave no reaction.
XX 90-120 Ka.S.—Buzzing of flies very short.
Ka.D. ——
Ka.O. ——
An.S. ——
An.D. ——
An.O. ——
XX 130-170 Ka.S.—Stronger buzzing.
Ka.D.—Same.

XX 260-400 Ka.S.—Rumbling of cannon.
Ka.D.—Same >
Ka.O. ——
An.S. ——
An.D. ——
An.O.—Rumbling of wagons.
XX 410-550 Ka.S.—Striking of metallic plate.
Ka.D.—Same >

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* Op. cit., Band i. p. 105.

	Ka.O. ——		Ka.O. ——
	An.S. ——		An.S. ——
	An.D. ——		An.D. ——
	An.O. ——		An.O.—Rumbling.
XX 180–250	Ka.S.—Distant rumbling of wagons.	XX 560–	Ka.S.—Sharp ring like a silver table-bell.
	Ka.D.—Same.		Ka.D.—Same. >
	Ka.O. ——		Ka.O. ——
	An.S. ——		An.S. ——
	An.D. ——		An.D. ——
	An.O.—Buzzing of flies.		An.O.— Weaker and shorter ringing.

Erb * gives the following result of experiments on himself:

10 El.	Ka.S.Kl.——	8 and 6 El.	Ka.S.Kl.
	Ka.D.Kl >		Ka.D. ——
	Ka.O. ——		Ka.O. ——
	An.S. ——		An.S. ——
	An.D.		An.D. ——
	An.O.Kl.		An.O. ——

On another patient, † 50 years of age, he obtained the following reaction with accompanying symptoms of pain and facial contortions.

8 El. Ka.S.—Clear whistling, stinging pain and facial contortions.
Ka.D.—Gradually disappeared.
Ka.O.—No sensation.
An.S. —Violent pain.
An.D.—Pain remains.
An.O.—Short and weak whistling; slight facial convulsions with 10 el.; the same formula gave still louder sensations of sound, but the accompanying pain was very severe.

As illustrative of the variations, in the character and intensity of the sound, we present a few cases from several authorities. For convenience' sake we use the terminology and the abreviations above explained.

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* Archiv. Opthalmology and Otolog., vol. i., No. 1, p. 246.

† Loc. c., p. 250.

Brenner* gives the following reaction in a healthy man :—

	Same patient treated by a stronger current.
Ka. S. —Rumbling of cannon.	Ka. S. —Sharp ringing.
Ka. D. " " "	Ka. D.— " "
Ka. O.——	Ka. O.——
AS. ——	AS. ——
AD. ——	AD. ——
AO. —Rumbling of wagons.	AO. —Weaker and shorter ringing.

The variations of the tone with the difference of the current are represented in the following experiment of Brenner : †

With the cathode closing.	With anode opening. (An.O).
XX 10 Ka. S. K.	XX 30 A. O. K.
20 Ka. S. K.	40 A. O. K.
30 Ka. S. K.	50 A. O. K.
40 Ka. S. K'.	60 A. O. K.
50 Ka. s. K'.	70 A. O. K.
60 Ka. S. K'.	80 A. O. K'.
70 Ka. S. K''.	90 A. O. K'.
80 Ka. S. K''.	100 A. K'.

Changes in the reaction of the auditory nerve in pathological cases.

In pathological cases the normal formula above given may undergo various changes.

These changes may be embraced under the following heads : ‡

1. *Hyperæsthesia of the nerve*, so that it reacts to a milder current than normal, or reacts longer or more powerfully. This may be either simple or complicated with qualitative change in the formula, or with paradoxical formula in the ear not experimented on, or with morbid subjective sensations of hearing.

2. *Change in the formula of reaction without hyperæsthesia.* These changes are either in inversion of the normal formula, or deviations of various kinds.

3. *Torpor of the nerve* (*anæsthesia*), so that it does not react or only to a stronger current than normal.

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* Op. cit., Band 1, p. 106.

† Loc. cit., p. 110.

‡ Brenner, op. cit., Band i., p. 181 et seq.

We thoroughly agree with Brenner and Erb that these reactions of the auditory nerve are obtained by the *direct* action of the current on the nerve, and not by *reflex action* through the trigeminus. This view is proved by the general fact of the conductibility of the tissues of the brain (p. 89), by the fact that even when the trigeminus is paralyzed the reaction may yet occur,[*] and by the fact that when the electrode is placed in a condition favorable for the entrance of the current into the ear, the reaction is more decided than when the electrode is placed in a condition favorable for the excitement of the trigeminus, but unfavorable for the direct entrance of the current, as has been conclusively shown by Erb[†] and by ourselves.[‡] We have removed the pole from the *tragus to the malar bone and the cheek, both of which points are highly favorable for the excitation of the trigeminus, and have found that with removal the reaction diminished or disappeared.*

Illustrative pathological cases.—Brenner gives the following illustration of hyperæsthesia in a case of chronic catarrh of the middle ear, on both sides, with difficulty of hearing, much *tinnitus.*

The reaction was as follows :

XX 90 Ka.S.K.
Ka.D.K. ∞
Ka.O.—
A.S. —
A.D. —
A.O.k. >

In another case where there was great difficulty of hearing, with tinnitus, that had existed for three years and demonstrable anatomical changes, but in which a central disease was suspected, the reaction was as follows :[§]

XX 50 Ka.S.K'.
Ka.D.K. ∞
Ka.O.—

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[*] Vide Moos' case, above quoted in Archiv Ophth. and Otol., vol. i., No. 2, p. 482.

[†] Archiv Ophth. and Otol , vol. i., No. 1, p. 261 et seq.

[‡] For a detailed discussion of this subject, see Brenner's work, Band i., 1 Abth., p. 94, et seq.

[§] Op. cit., p. 90, 191.

A.S. —
A.D. —
A.O.k. >

Other cases, illustrative of changes of various kinds, we give below :—

Qualitative change.—A laborer, 30 years old; intelligent; deafness and tinnitus on both sides from childhood; drum cloudy and thickened.

X 100 Ka.S.K'.
Ka.D.K. ∞
Ka.O.—Rattling.
A.S. "
A.D. " ∞
A.O.K. >

*Hyperæsthesia with inversion of the normal formula**.—A lady of sixty; absolute deafness in left ear; drum depressed, thickened and opaque.

6 El. Ka.—
Ka.D. —
Ka.O.Pf. >
An.S.Pf.
An.D.Pf. ∞
An.O. —

Hyperæsthesia with paradoxical sensations in ear not treated.†

Ear treated.	Ear not treated.
XX 100 Ka.S.K."	——
Ka.D.K. ∞	——
Ka.O. —	K. >
A.S.	K'.
A.D.	k. >
A.O.K'. >	——

Illustrative and typical case of inversion of the normal formula.‡—An officer, 26 years old; from his childhood completely deaf in left ear; no tinnitus; no demonstrable change in drum; only a pale color; right ear normal.

Electric examination of right (healthy) ear gives this *normal* formula.	Electric examination of left (diseased) ear gives the *inverted* formula.
IX Ka.S.K'.	IX Ka.S. —
Ka.D.k. >	Ka.D. —
Ka.O. —	Ka.O.K.
A.S. —	A.S.K'.
A.D. —	A.D.K. >
A.O.k.	A.O. —

Modification of the normal formula without hyperæsthesia.—A woman, 45 years; old difficulty of hearing in both ears; no tinnitus; some dulness of the drums.

RIGHT EAR :—

XX 500 Ka.S.—"Chirping."
Ka.D. " short.
Ka.O.
A.S. —Roaring.
A.D. " short.
A.O. —Indefinite sounds.

Left ear gave same formula, except that Ka.O. gave a short and slight roaring.

The above case of the officer Brenner regards as of a special nature. The patient was examined by a number of aurists, and the inversion of the normal formula in the diseased ear was decided.

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* Erb in Archiv Ophth. and Otol., vol. i., No. 1., p.272.

† Brenner, op. cit., Band i., p. 205.

‡ Brenner, l. c., p. 219.

The following experiments were made by one of the authors of this work on himself. The right ear, on which the experiment was made, has for 25 years been affected with chronic inflammation of the middle ear. The drum is cloudy, the tube pervious, and the hearing distant; at times he had been troubled with tinnitus, but not at the time of the experiment. The objective examination of the ear was made by Dr. D. B. St. John Roosa. The experiments are given in detail, because they illustrate a number of the peculiarities in regard to the galvanic reaction of diseased ears.

The *internal* method was used:

10 Stöhrer's El. Ka.S.—No reaction
Ka.D.—Some rumbling, made evidently by pressure of electrode.*
Ka.O.
An.S. —No reaction.
An.D.— " "
An.O.— " "

12 El. Ka.S. —No reaction.
Ka.D.— " "
Ka.O. — " "
An.S. — " "
An.D.— " "
An.O.— " "

Feeble flashes of light were observed. The rumbling of a distant carriage for a moment was mistaken for the cathode closing reaction.

16 El., Ka.S.—No reaction.
Ka.D. - Hissing in the other ear; (paradoxical reaction.)
Ka.O.—Same for a moment.
An.S. —Hissing.
An.D.—Same >
An.O.—No reaction, but hissing in other ear.

Stronger flashes of light; dizziness; subjective sounds in ears for some minutes after treatment.

20 El. Ka.S.—Slight roaring.
Ka.O. >
Ka.O.— No reaction.
An.S. —Loud hissing (seething).

Rheostate—600—Same roaring.
700— " "
800— " "
900— " " still pain.

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* In order to prevent deception on this point, the finger was pressed on the tragus, and found to produce the same apparent sensation of rumbling. The apparatus used in this experiment had no current reversor, consequently it was necessary to continually move the electrode to and from the tragus.

An. D.—Same >
An. O.—No reaction.

Considerable pain in ear; much stronger flashes and dizziness; metallic taste; burning in wrist of the hand holding cathode.

The rheostate was now brought into use.

24 El. K. S.—Low rumbling and hissing in other ear; very great pain; perspiration on forehead, and muscular contractions.
Ka. D.—Same ∞
Rheostate—100—Same roaring.
200— " "
300—Less "
400— " "
500— " " less pain.
1,000—Much less roaring, and hissing in other ear much less.
Ka. O.—No reaction.

The anode reaction with the resistances of the rheostate was as follows:

An. S.—Very loud hissing.
An. D. ∞ and flow of saliva.
Rheostate—100—Very loud hissing.
200— " " "
300— " " "
400—Loud "
500— " "
600—Less "
700— " "
800— " "
900— " "
1,000—Much less "

Concerning the above case it may be remarked:

1. The deviation from the normal formula was unmistakable. The anode reaction was very decided, there was no possiblity of a mistake. The chief difficulty was with the cathode. A low rumbling or roaring was all the reaction that could be obtained with Ka.S. or Ka. D. and that only when many elements were used.

2. The accompanying phenomena—dizziness, pain, contractions of the facial muscles, metallic taste, flow of saliva, perspiration on forehead, burning and contraction of the muscles of the hand holding the electrode—were present, but did not interfere with the observation of the reaction of the nerve. It is just, however, to remark that this individual has been accustomed for many years to experiment on himself with electricity, and therefore would be little liable to be annoyed or distracted by their incidental phenomena; yet even he was deceived momentarily by the rumbling of a distant wagon. Constriction of the throat, of which some complain, was not experienced.

3. The use and value of the rheostate was demonstrated, although not to a marked degree. The sound sensibly diminished with the increase in the number of resistances. It would not be

difficult to see that very different reactions might be obtained within the limits of these resistances.

The following pathological case is of double interest, since benefit to the hearing seemed to result immediately after the galvanic examination.

G. K. B., aged 18, had from his early boyhood suffered from chronic ulceration of the membrana tympani with discharge. In the left ear the drum had disappeared. The watch could be heard only on pressure. There was no tinnitus. The eustachian tube was pervious.

Three years before the right ear had been similarly affected, and had entirely recovered under the influence of treatment, so that the discharge ceased and the hearing was normal. At that time Dr. St. John Roosa saw the case in consultation and confirmed the diagnosis.

August, 1820. The patient again consulted us for his right ear, which we found in the condition described, and which was similar to that in which we had found it three years before. At this time we decided to test the galvanic reaction, which we were able to do without difficulty, by the external method. The result was as follows :

8 El :	Ka. S.	Some rumbling.
	Ka. D.	" "
	Ka. O.	No sensation.
	An. S.	Rumbling.
	An. D.	"
	An. O.	No senation.

With 10 and 12 elements there was the same, but louder, and with 18 elements a sound like the ringing of a large bell, reaction. When 16 elements were used, the patient experienced a sensation of hissing with An. S. and An. D.

After various changes of the current, a less number of elements brought a decided reaction. In order to see whether the patient deceived himself, or whether the sounds were produced by the agitation of the water in the ear, we applied the electrode to the tragus, when disconnected from the battery.

Immediately after the sitting the patient said that he could hear conversation better. The week following the same experiment produced the same result. During the interval magnesia had been blown into the ear in considerable quantities, so as to interfere somewhat with the hearing power; for that reason it was impossible to determine whether the improvement was permanent.

Dizziness in this patient was very marked and lasted by terms for several days.

In order to make these experiments successfully either on healthy or pathological cases, and especially in order to make them with such accuracy and confidence as to invariably distinguish between the healthy and diseased ear by the character of the reaction, the following conditions are essential:—

1. *Convenient galvanic apparatus.* Although the auditory nerve may react to the faradic current, as Brenner has shown,* yet on account of its less power of overcoming resistance, and the fact that the reactions can only take place during the very rapid interruptions of the current, it can be made of but little service in making these nice distinctions. A very powerful battery is not needed. The range of elements to which the auditory nerve sensibly reacts is between 2 to 20. In some cases very strong currents are necessary. The galvanic batteries and electrodes described in this work are adapted for these investigations. There should be a current reversor.

2. *A right method of application and practice in using it.*

On the whole the best method of application to produce these reactions is the *external* arrangement, in which one pole is firmly pressed on the tragus (the ear external auditory canal having been previously filled with warm salt water), while the other is held in or fastened on the hand of the opposite side. Any convenient electrodes may be used for these purposes.† So long as the pole whose specific effect we desire to produce is on the right place in the ear or on the tragus, the position of the other electrode is not absolutely essential, provided it is somewhere *on the opposite side, so as to allow the current to pass through the auditory nerve.* It is difficult or impossible to get the reaction while the pole is on the mastoid process of the same side. It has been shown that when both poles are placed in the auditory canal by means of a double electrode, the auditory nerve reacts to the nearer pole.

A number of intelligent and practised patients with both healthy and diseased ears.

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* We do not mean by this remark to give the impression that electricity can be mathematically measured by the number of elements. Much depends on the size of the element, the strength of the solution, the extent to which it has been used, and the condition of the atmosphere from day to day. Stöhrer's elements are of about the average strength.

† Pp. 101-103.

The advantages of intelligence on the part of the patient are obvious. Just as in investigating electro-muscular sensibility it is necessary to depend entirely on the statements of the patient for our information. Even the strong-minded and intelligent are sometimes so distressed by the pain produced by the applications, or so distracted by the sensations of *dizziness*, and the *contractions of the facial muscles*, that they are unable to rightly interpret their subjective sensations in the ear. It is necessary that the experiments should be made on a number of patients in order to obtain the variety of reactions that are described by Brenner.

It is best also to make the first experiment on patients who have diseased ears, for it is as true of the auditory as of the nasal passages that they become less sensitive when diseased. This is to be explained partly by the manipulations and treatment to which such patients become accustomed, and partly by the fact that the morbid process itself produces callousness of the parts.

The operator should proceed calmly and with self-command. After the patient is in position, with his head inclined on the back of the chair or lounge, and one of the electrodes fastened to or held in the hand opposite the ear to be experimented on, a little warm salt water should be dropped in (which can be very conveniently

If the battery is provided with a *commutator*, for increasing and diminishing the number of elements brought into requisition, a *current reversor* for changing the direction of the current without removing the poles, and a *rheostate* for *introducing resistances* into the circuit, the labor of the operator will be materially lightened, but such appliances are not indispensable. The operator should remember that the reactions are modified by the experiment itself.

(*a*) Ka.S is most effectual after An.S. Therefore the use of *voltaic alternatives* is of service.

(*b*) The excitability of the nerve is increased by long closure of cathode (Ka.S.)

(*c*) The excitement of An.O. increases with the strength of the current and the length of closure.

It should be remembered also that Ka.S. is stronger and quicker than An.O.

Judging from our own researches in this department these three leading statements of Brenner, that the auditory nerve reacts to the *nearest* electrode in a regular manner, that in health sounds of some kind are produced at the closing and in the duration of the cathode, and that in pathological cases a part of the normal formula is more or less changed—are capable of sufficient and easy demonstration to those who are thoroughly familiar with electro-therapeutical experimentation.

On the other hand, some of the special features of Brenner's system offer difficulties in the way of their successful and uniform demonstration that can only be overcome by careful practice in this special department. To catch the sounds which in health are heard at the opening of the anode; to distinguish between the noise caused by the agitation of the water in the ear, and the subjective sounds that are so frequently the symptoms of disease of the auditory apparatus and the genuine reaction of the auditory nerve; to obtain the *complete* normal formula in health and to satisfactorily discriminate between the various abnormal reactions of disease—the first attempt to fully corroborate all the assertions in these particulars will usually result in complete or partial failure, especially to those who are unfamiliar with the use of galvanic apparatus.

Among the special conclusions to which Brenner has been led by his researches are the following:—

1. Disease of the auditory nerve is frequently complicated with and results from disease of other parts of the ear. This complication is seen not only in long standing, but sometimes in recent cases, as in catarrh of the middle ear.

2. Absolute deafness and want of conducting power of the bones are no necessary evidence of disease of the auditory nerve.

3. The causes of the changes in the normal reaction of the auditory nerve to the galvanic current may be either in the nerve or in other parts of the ear.

The changes in the auditory nerve are ***hyperæsthesia, torpor,*** (anæsthesia) or other peculiar modifications of its function.

The changes in other parts of the ear are ***deposits of morbid products, growth, suppuration, wounds, defects.***

Degrees of Irritability.—Brenner distinguishes three different degrees of irritability of the auditory nerve, according to the number of elements that it takes to excite the reaction. The degrees of irritability may be changed during the sitting by the effect of the eurrent on the nerve, and especially by the voltaic alternatives.

Thus, if at the beginning of the sitting the nerve reacted to 16 elements, but to no number less than that, these 16 elements would represent the primary *irritability* of that nerve.

If by various alternations of the current the nerve is brought into a condition that it reacts to 12 elements, these 12 elements represent the *secondary irritability* of that nerve.

If, by still further excitation, the nerve is made to react to 10 elements, these 10 elements represent the *tertiary excitability* of that nerve.

Treatment of Diseases of the Ear.—In addition to the general reasons already presented for the backward and unsatisfactory condition of the electro-therapeutics of the ear, two other special reasons may be adduced.

1. The comparative infrequency of purely nervous diseases of the ear. Formerly the diagnosis was made frequently and indiscriminately; now it is made but rarely and chiefly by exclusion.

On this point Tröltsch * observes, "With every increase of our knowledge of the morbid processes taking place, this side of the labyrinth, and with every improvement of our method of examination, the field of nervous affections of the ear becomes smaller."

2. The fact that very few aurists or electro-therapeutists have tried electrical treatment, even in those cases of deafness for which it would appear to be indicated.

It would seem from the researches of Brenner that the auditory nerve is more or less implicated in many cases of deafness dependent on changes in the drum and middle ear, and that in all such cases electrical treatment is indicated.

Treatment with the Faradic Current.—Brilliant cures have been accidentally accomplished, from the very earliest history of these experiments; but, for the reasons mentioned, they were exceptional, occasional, and could not be scientifically reported.

In the United States, cures of deafness have occasionally been accomplished by uneducated empirics, who have treated all forms of disease of the ear, from inspissated cerumen to disease of the auditory nerve, by some unscientific and uniform method of faradization.

Duchenne reports one case by faradization of hysterical deafness of many months' standing; one caused by quinine; one consecutive to an eruptive fever; one following measles; one of twenty years' standing. Several cases of nervous deaf-muteism were also improved.

The conclusions to which he arrived are as follows: †

1. "That nervous hysterical deafness is generally caused by electrical excitation of the *chorda tympani* and movements of the chain of little bones."

2. "That cases of nervous deafness consecutive to eruptive and continued fevers have been cured by the same treatment, even though they have been of long standing, and, from the fact

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* Treatise on Diseases of the Ear. Translated and edited by D. B. St. John Roosa, second American edition, 1869, p. 496.

† Op. cit., pp. 1013, 1030.

of their resistance to ordinary remedies, have appeared to be incurable."

3. "That probably the therapeutical action of the process of faradization is chiefly due to the undulations of the labyrinthine liquid produced by the movements of the chain of little bones, and consequently of the *fenestra ovali.*"

4. "That electric exploration of the ear furnishes no pathognomonic sign which permits the prognosis of incurability of the deafness."

Chronic Inflammation of Middle Ear.—As far as we can judge from our own observations, old cases of chronic inflammation of the middle ear, where the hearing power is so much impaired that a watch can be heard only on pressure, offer an unfavorable prognosis.

The best results are obtained in those cases that are just passing from the subacute to the chronic stage. We are inclined to the belief that these results, when they do occur, are brought about by the *mechanical action of the faradic current, on the adhesions within the middle ear.* In some even long-standing cases of chronic inflammation of the middle ear temporary improvement of hearing immediately follows faradization.

of the ear, Brenner* and Hagen† substantially agree to the following conclusions:

1. The galvanic current is indicated not only for those cases where no morbid changes can be diagnosticated, but also in all cases, however complicated, in which the abnormal reaction to the current shows that the nerve participates in the disease.

2. The galvanic treatment may aid in the absorption of morbid deposits.

From our survey of the literature of the subject, and from our own comparative observations, we are justified in stating with positiveness that the galvanic current is on the whole of greater service, and is of greater promise in the electro-therapeutics of the ear than the faradic.

The results obtained in the electric examinations are not uniform or always reliable guides to the special method of treatment that it is best to adopt.

Reasoning *à priori*, it would be inferred that the reaction of *hyperæsthesia* would call for treatment by the *anode*, and the reaction of *torpor* (anæsthesia) for treatment by the *cathode;* but experience shows that there is no uniformity to this law.

Moos,‡ in the remarkable case to be hereafter cited, found that the cathode at one time exercised a temporarily beneficial influence on the subjective symptoms, which usually disappeared only under the anode.

Erb§ also, in case of "*simple hyperæsthesia* of the right *auditory nerve*," with "*inversion of the normal formula*," found that the tinnitus was quieted by the closing of the cathode (Ka.S.) and not by the closing of the anode as would have been expected.

Still further, it is not demonstrated that in many of the cases of hyperæsthesia that were successfully treated by the anode, or of torpor (anæsthesia) that were successfully treated by the cathode, the results might have been equally or more successful if the poles had been reversed. The conclusion is, therefore, that while the general law laid down on page 165, that *the positive pole is on the whole the more calming and the negative the more irritating*, applies to the auditory nerve, as to other parts of the body, yet it is always liable to many real or apparent exceptions, and in the present state of our knowledge of the system the rule can never be made an absolute or uniform guide in the electro-therapeutics of the ear.

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* Op. cit., Band i., p. 262.

† Praktische Beiträge zur Ohrenheilkunde, Leipzig, 1866, p. 29.

‡ Archives Ophthal. and Otol., vol. i., No. 2, p. 488.

§ Archives Ophthal. and Otol., vol. i., No. 1, p. 28.

Brenner * details 11 cases of diseases of the ear treated by the galvanic current.

In one case of thickening of the drum, the current caused absorption.

In one case of hyperæsthesia, with tinnitus aurium and anatomical changes in the middle ear, the tinnitus was rapidly cured.

In one case of hyperæsthesia, after the use of quinine there was recovery.

In one case of hyperæsthesia, with tinnitus aurium and catarrh of the middle ear, the tinnitus was cured.

In one case of obstinate subjective symptoms of various kinds there was improvement under great difficulties of application.

In one case of noises in the head and ears of ten years' standing, with important anatomical changes in the ear, there was improve-with the patient by writing. This deafness was preceded by ***abnormal sensitiveness of the ear, and distressing acuteness of hearing.*** Two weeks afterwards, the ninth week of her sickness, the sensitiveness had diminished and her deafness was absolute. In the eleventh and twelfth weeks of the disease she began to suffer from ***hysteria or epileptic attacks***, lasting for a half to one and a half hours, from one to three times a day. These attacks were accompanied by loss of consciousness, tetanus, clonic cramps, and pains in the back and abdomen. There was also ***unilateral hyperæsthesia*** of the scalp and face.

These symptoms were variously treated by the galvanic current. The patient was treated with the galvanic current, at first daily, from May 10th to July 27th.

At first there was, as has been stated, a feeble reaction to the current. This was followed, in a few days, by ***simple hyperæsthesia***, combined with a ***paradoxical reaction*** in the ear not treated, and lastly hyperæsthesia *with qualitative change.* When the cure was complete the normal formula of Brenner appeared.

On the eleventh day of the treatment the patient heard her own voice in the left ear, *immediately after the galvanic treatment.* Noises in the ear appeared which were treated by the anode. On the 18th and 24th of June, conductibility of the tones was noticed for the first time. July 12th, two months from the beginning of the treatment, the patient could hear the watch on the right side 10 feet, on the left 9 feet. The treatment now caused dizziness, which made it necessary to give longer intervals during the séances, and it was found necessary to use very weak currents. The patient was now sent to Black Forest, where in six weeks she fully recovered.

On the 29th of April, Dr. Moos, an experienced aurist, who had once before examined the patient, came to the conclusion that there was ***perfect paralysis of both auditory nerves.*** The ***electric examination***, made on the 9th and 10th of May, gave the following result :—

RIGHT EAR.	10 El. 900 cR*	K.S.	—Lively whirring sound.
		K.D.	—Same gradually disappearing.
		K.O.	—No result.
		An.S.	— “ “
		An.D.	— “ “
		An.O.	— “ “
LEFT EAR.	10 El. 400 cR	K.S.	—Scratching of a violin.
		K.D.	—The same, lasting a short time.
		K.O.	—None.
		An.S.	— “
		An.D.	— “
		An.O.	— “

The ears were differently affected. On the right side there was “paralysis of the auditory nerve, paralysis of the sense of touch, as well as paralysis of the trophic nerves, decubitus of the right concha." On the left side there was "paralysis of the nerve of hearing, long continued hyperæsthesia of the nerves of touch."

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* Resistances of the rheostate.

Concerning this case we may remark :—

1. It was unquestionably a case of *hysteria* as we have defined that term (see p. 312) of which the rheumatic affection was the exciting cause.

2. Although the element of time should not be ignored, yet the recovery was mainly due to the electrical treatment. This is proved by the *immediateness and rapidity* of the results.

3. The case establishes, so far as a single case can, the substantial correctness of the main propositions of Brenner.

4. It is not demonstrated that the *exclusive* use of either pole was necessary to obtain the result, and it is entirely probable that the faradic current might have been of more or less service.

Moos* relates a case of cerebro-spinal meningitis that was followed by complete deafness, that gradually improved so that he could hear one or two feet. The patient was troubled with tinnitus aurium and also with headache and vertigo. With the right ear he heard nothing; with the left ear could hear the voice two feet.

We have obtained a perfect cure in one marked instance by this method of treatment.

The evidence is accumulating that both the general and the special propositions of Brenner are, in the main, entirely demonstrable to all who, with the requisite facilities, conduct their experiments with sufficient skill and perseverance.

The same opposition which Brenner has encountered has been directed against every original explorer in electro-therapeutics. Science is and should be sceptical; but its scepticism should be based on intelligence and not on ignorance, for, as Whately very truly observes, he who rejects reliable evidence is really more credulous than he who accepts it, for of two suppositions, he believes that which is the more improbable.

Those who live in memory of the times when the now established principles of Duchenne were regarded with indifference or disbelief; when the discoveries of Remak, that have so enriched and enlarged the sphere of electro-therapeutics, were laughed to scorn in the scientific centres of Europe; when the idea that electricity could be made available for the improvement of nutrition and the improvement of the general functions was universally dismissed without discussion—ought certainly to be slow in doubting and still slower in rejecting even the most radical statements in electro-therapeutics that have passed the crucial test of experience at the hands of any intelligent observer.

In conclusion we may call the attention of aurists and of electro-therapeutists to these three propositions, which are, we believe, legitimate and necessary inferences from the facts that have been presented, and which, we feel assured, will be amply sustained and reinforced by the experience of the future :

1. The method of diagnosticating the condition of the auditory nerve by the galvanic current in diseases of the ear, with all its necessary difficulties and imperfections, is yet of such decided value as to entitle it to a faithful trial in all delicate and doubtful cases.

2. Cases of nervous deafness or of deafness resulting from various pathological conditions with which a morbid condition of the auditory nerve is complicated, and all cases of *tinnitus aurium*,

whatever may be their supposed pathology, should only be regarded as hopeless after the failure of persevering and varied treatment by electricity, although perfect or approximate cures will be obtained only in a small percentage of the cases.

3. The treatment of opacity and thickening of the drum and of chronic inflammation (with the consequent adhesions and other morbid changes) of the middle ear and eustachian tube, offers a fair and important field for electrical experiment.

It can hardly be expected that every one who studies the department of aural surgery can alone carry out these elaborate experiments. The most successful results will probably flow from the harmonious coöperation of the two specialties, who should unite their forces and divide their labors. The electro-therapeutist should appeal to the diagnostic skill of the aurist, and the aurist will do well to avail himself of the technical experience of the electro-therapeutist.

CHAPTER XXXIV.

RHEUMATISM.

RHEUMATISM is a disease for which electricity, by various methods of application, has been employed with more or less success, from the early periods of the history of electro-therapeutics. Next to paralysis, it is perhaps the disease in which the original experiments of electro-therapeutists were most frequently conducted; and for the reason that (like paralysis) it is so frequently obstinate to ordinary remedies. It is now established that although certain stages of rheumatism, especially the muscular and subacute, and the chronic, when not too long-standing, yield sometimes rapidly to electrical treatment, yet it is by no means the leading or principal disease for which electrization is indicated.

Treatment.—Rheumatism is a constitutional disease, and demands constitutional treatment. The best results are obtained by general faradization, combined with faradization or galvanization of the affected joints. To confine the treatment to the affected joint is unphilosophical, and usually more or less unsatisfactory, for the obvious reason that it attacks merely a local symptom, which at any time may be transferred to other and remote parts of the body. The true method is to lay the axe at the root of the tree by making the applications general, so as to bring the whole system under the influence of the current. This treatment sometimes causes increase of the flow of urine, and almost always more or less exhilaration, and relief of the pain. Special attention should be given to the parts which are chiefly affected, and the swollen joints should be treated by mild and steady faradization or galvanization. Where in the acute or subacute forms the immediate effects are agreeable, it is probable that continued treatment will be of service. For the local treatment the galvanic and faradic current may be used alternately.

The effect of the current on the inflamed joints is to relieve the pain, reduce the inflammation, and, where effusion has taken place, to cause absorption. Absorption may be caused by both currents, in some cases more powerfully by the galvanic. If the currents are used too strong or too long, the pain and inflammation may be increased. For applications to very sensitive and painful joints, the *positive* pole is preferable (see p. 165). For rheumatic callosities and anchylosis, *very prolonged* local applications of the galvanic current may be tried.

Prognosis.—In presenting the prognosis of rheumatism great stress must be laid on the distinction between the chronic, *subacute, and muscular varieties.*

During our earlier investigations in electro-therapeutics we treated perhaps as many cases of rheumatism as of any one class of disease. The apparent results of treatment by electrization in many cases of muscular, and in a number of cases of the acute, subacute, and chronic varieties of articular rheumatism, excited our enthusiasm, and led us to hope that a remedy had been found that would prove very generally and powerfully remedial in all forms of this disease. Further experience and investigation compels us to declare that we are not to expect such rapid and decided verity as to render any of the muscles of the body almost if not quite powerless.

Rheumatic paralysis—Decided relief under general faradization.

CASE 145.—The sufferer was a little boy, who for several months had been afflicted with both acute and chronic muscular rheumatism. The sterno-cleido-mastoideus and the platysma-myoides muscles were very rigid, and frequently contracted violently, causing acute pain. The patient was unable to bring his jaws nearer to each other than one-half an inch, while it was impossible for him to turn the head on either side, without at the same time turning the whole body.

The entire head was exceedingly sensitive to slight pressure with the fingers. The first application was made with an exceedingly mild and fine faradic current, and was of 10 minutes' duration. With the hand and fingers as electrodes, we carefully manipulated the head, neck, and individual muscles, until the patient could close his mouth and turn his head to either side with some freedom, and without suffering pain or inconvenience.

In about a week, the patient again presented himself. He could still close his jaws firmly, but was unable to turn his head as readily as before. A second application relieved him as completely as the first. To our regret we saw no more of this case after the second visit, but learned subsequently, however, that he retained the improvement, and, under internal medication, recovered.

Intercostal rheumatism of long standing—Improvement under general faradization.

CASE 146.—A gentleman, sent to us by Prof. Austin Flint, was approximately cured of chronic rheumatism that chiefly affected the intercostal muscles.

For nearly three years he had suffered, from time to time, attacks of more or less severity, although at no time since the disease first manifested itself had he been entirely free from it.

It was a singular feature of his disorder that it was aggravated by the warm weather of spring and summer. He was treated by general electrization with the faradic current every other day for six weeks. He gradually improved, and, when treatment was discontinued, he remained comparatively free from any symptoms of his late disorder.

Subacute articular rheumatism—Muscular soreness and enlargement of joints relieved by three general faradizations.

CASE 147.—By the courtesy of Prof. Austin Flint we treated, in October, 1867, a case of subacute articular rheumatism in one of the wards of Bellevue Hospital. For three months the patient had suffered from muscular soreness of the back and shoulders, and a considerable enlargement of the right wrist and ankle and the joints of the first toes of the feet. Three general applications, with special reference to the diseased parts, dissipated the muscular soreness, and so decidedly relieved the lameness and reduced the enlargements of the joints that the patient was discharged from hospital in three weeks.

Chronic rheumatism of seven years' standing, accompanied with great pain —Increase of pain and no temporary improvement under very mild faradization and galvanization.

CASE 148.—Capt. L., aged 43, was first seen by us Sept. 30, 1868. For seven years the patient, who was a pilot by occupation, had been a very great sufferer from chronic rheumatism that affected all the limbs. The swollen parts were excessively painful on movement, and the patient was thoroughly crippled. Cautious applications of the faradic current gave no relief, and positively increased the pain for two or three days after each séance. The galvanic current produced the same effect to a less degree, and the treatment was abandoned.

Both acute and subacute rheumatism occasionally occur complicated with neuralgia and nervous exhaustion, and are usually very persistent.

Subacute rheumatism—Right deltoid muscle and several joints and fingers and left knee affected—Debility—Recovery under general faradization.

M. Cherron* reports excellent results in the treatment of chronic rheumatism by the galvanic current.

He observed the following effects :—(1) relief of pain, (2) prevention of atrophy of the muscles, (3) relief of deposits, (4) tonic effects on the constitution.

The treatment acted on the system generally, "improving the nutrition, and thus not only moderating the dyscrasia, but eliminating it from the body altogether, as is manifested by the permanent relief obtained." Cherron's method of application is not given. (For treatment of rheumatic paralysis see p. 383.)

MYALGIA (MUSCULAR RHEUMATISM).

This name is commonly applied to neuralgic or rheumatic pain of the muscles on movement, caused usually by exposure to cold or dampness. It may be distinguished from ordinary neuralgia—first, by the fact that the pain occurs chiefly on movement and not on rest ; and, secondly, by the fact that the soreness is diffused through or over the muscles, and not seated or fixed in certain nerve tracts. It receives different names according to its locality. In the back it is called *lumbago ;* in the thoracic muscles, *pleurodynia ;* in the neck it simulates torticollis or wry neck so closely as oftentimes to be confounded with that affection (see Torticollis).

Treatment.—Local faradization with a mild current, either stable or labile, usually relieves such cases in a short time. Stable galvanization also with a mild current may be at once effective. Severe applications may increase the pain in this affection. The fact that the patient is not at once relieved, or is worse after the first application, should not discourage us, since the final result may be satisfactory. Of the large number of cases that we have treated, nearly all have been relieved by one, two or more applications. A single application, with a *mild* current, prolonged for one or more hours, may sometimes entirely dissipate an attack of myalgia.

It is in myalgia that the belts, chains, bands, disks, etc., worn on the body, have obtained the best results. A convenient arrangement for making prolonged or continuous local applications of very mild galvanic currents is the electric disk of Dr. Garratt.

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* *Giornale Veneto di Scienze Mediche, December,* 1869 (quoted in *Practitioner,* July, 1870).

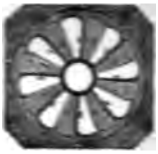

FIG. 87.—CIRCULAR DISK.

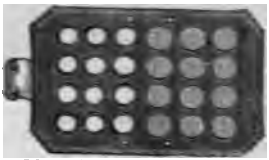

FIG. 88.—OBLONG BUTTON DISK.

These are made of alloy—magnesium and zinc—for the negative, and silver for the positive pole. The surface of the body forms a moist connection between the pairs, which are insulated by thin rubber. The disk is made in two general varieties—the circular and the oblong,—the latter being used for the limbs or back; the former, which is very flexible, can be applied to almost any portion of the body.* The very slight galvanic action of these disks, which is excited by the moisture of the body, may be increased by wetting the skin beneath them with salt water. They should only be worn a part of the time, either in the day or night. They may be used for weeks and months.

That these and other similar contrivances, when scientifically constructed, may relieve slight *local and superficial* pains, there is no question. In the treatment of deep-lying affections of the brain, spinal cord and viscera, or severe neuralgia, very many important results have not yet been reported for them. The results that appear under their use may, perhaps, be sometimes explained in part by their effect on the imagination of the patient, and by the counter-irritation which they unquestionably excite when long worn. (See pp. 137, 366.)

It is a fact of interest that continuous application of electricity is a revivification of a method that was rudely attempted as long ago as the days of Pliny, when necklaces of amber were worn by women and children for the sake of their remedial properties.†

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* For sensitive patients, and especially for ladies, the oblong "button-disk" is usually to be preferred, on account of its greater lightness and flexibility.

† See the Report to the Academy of Sciences on *The Application of Electricity to Therapeutics.* By M. Becquerel and others. Translated by E. S. Dunster, M.D.—*Psychological Journal,* October, 1869, p. 284.

As typical of the results of treatment in cases of ordinary severity, we present the following:—

Muscular rheumatism of right arm and shoulder of several months' standing —Recovery under general faradization.

CASE 150.—A young lady suffered almost constantly for several months during one winter from a persistent lameness of the right arm and shoulder.

Toward spring the affection became less troublesome, and finally ceased to annoy her. During the month of December of the following winter the old difficulty returned, and after several weeks it seemed probable that it would prove as obstinate as the previous attack. About this time she submitted to treatment by general faradization, and immediately experienced considerable relief.

In a few hours the dull aching of the muscles returned, and on the following day the same treatment was followed by the same marked amelioration of the pain and lameness. She was thus treated every day for a week, the recurring symptoms being less severe after each visit, until after the seventh she ceased to be annoyed by them. During the remainder of the winter her system continued free from the disorder.

Gout.—In the chronic form of gout faradization is sometimes of essential service. General faradization may be tried with the hope of raising the tone of the system, and so as to enable it to better cope with the disease. Temporary relief of the pain may be derived from either local galvanization or faradization; but anything like a permanent removal of the disease is not to be expected from any form of electrical treatment.

With some gouty patients the electrical treatment acts so decidedly that we are disposed to resort to it during the subsidence of each attack, to relieve the pains and hasten recovery. Galvanization of the affected joints does not seem to produce the absorbing or catalytic effect that could be desired, and, if too prolonged, certainly aggravates the condition. Whether any benefit can be derived from any form of electrization during the acute stages, we are unable to say. The treatment of gout by electricity belongs to the early mythical era of electro-therapeutics, since, according to Appian, the shock of the electric fish—the torpedo—was used for the treatment of this affection as well as for paralysis.*

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* *Vide* above quoted translation of Becquerel's Report to *Academy of Sciences*, in *Psychological Journal*, October, 1862, p. 284.

Gout of thirty years' standing in a gentleman 60 years of age—Positive relief from general faradization in the subsiding stage of an attack.

Case 151.—Mr. W——, a retired gentleman of 60 years, who had lived in considerable ease for a number of years, consulted us March 20, 1868. For thirty years he had suffered from attacks of gout, especially during the fall and winter seasons. When he first consulted us he was in the subsiding stage of a severe attack. We gave him four applications of general faradization that relieved his pains and seemed to hasten his return to his usual condition of health during the intervals. Subsequently the patient resorted to electrical treatment, with decided benefit. Whether the treatment had the effect to diminish the violence or frequency of the attacks, we have not been informed.

Rheumatic Gout (*Arthritis nodosa*).—This affection is neither gout nor rheumatism, but appears to be a distinct constitutional affection. It occurs most frequently in the delicate and the nervous, and may be regarded as essentially a condition of debility. It is very apt to affect the hands, fingers, and toes, and sometimes thoroughly cripples the patient.

Treatment.—This condition is most successfully combated by tonics, and electrization, more for its tonic effects on the system than for any special catalytic power over the enlarged joints. General faradization and galvanization of the sympathetic are the methods that experience has shown to be most useful in this very intractable malady.

Prognosis.—The prognosis in rheumatic gout is not favorable. The pains can be relieved, the sleep can be improved, and the system can be in every way strengthened by the electric treatment, and even the enlarged joints can be made to diminish in size, or at least to be less troublesome. As nearly all patients afflicted with rheumatic gout are in a condition of debility, the improvement experienced at first under general faradization is such as to lead them to hope for a permanent eradication of the disease. In this respect they are always disappointed. The disease may be held at bay, but is never banished. It is doubtful, indeed, whether the benefit is not entirely due to the tonic effects of the treatment on the system, and not at all to any special influence over the rheumatic gout.

Other remedies are so powerless in this affection that electrization is worthy of a trial for the sake of its general effects.

Rheumatic gout of seven years' standing, complicated with general debility—Improvement in strength under general faradization and local galvanization—No improvement in the affected joints.

Case 152.—Mrs. P., aged 30, married, was referred to us by Dr. John T. Metcalfe, with rheumatic gout in both knees and ankles, and in the right hand. For seven years, at different times, she had been troubled with attacks that had more or less crippled her. At the time we first saw her she was recovering from sickness and confinement, and the joints were in the subacute stage.

The patient was much debilitated, and for that reason we employed at first general as well as local faradization, with the result of manifest improvement in the sleep and in strength. Subsequently, galvanization of the joints was tried, but without any further improvement. Indeed an inflamed spot in the hand was made worse by the galvanization. The patient soon left for the country, and galvanization of the sympathetic was not tried.

CHAPTER XXXV.

DISEASES OF THE NOSE.

THE medical diseases of the nose for which the electricity is chiefly used are *rhinitis and anosmia.*

RHINITIS (CATARRH).

Subacute and chronic inflammations of mucous membranes are susceptible of electrical treatment—may, indeed, be permanently as well as temporarily relieved by it, though but rarely does it work an entire cure unless aided by other measures.

Aside from any chemical effect of the current, its mechanical action alone would be sufficient to theoretically account for the relief it gives to inflamed mucous membranes. Stellwag, speaking of irritants in general in the treatment of external inflammations of the eye uses the following language : "The irritation which they set up in the sensory nerves being carried over to the vaso-motor nerves, may cause a contraction of the caliber of the vessels when they are in a condition of relaxation. This is done by the excitation and invigoration of the atonic muscular fibres. The resolution of the inflammation is favored by the lessening or removal of the congestion, which is one of the causes of the unfavorable course."*

The theory is fully plausible that electricity operates to a less degree in the same way, for its primary effect is to increase the amount of blood in the mucous membrane to which it is applied, and experience shows that this hyperæmic condition thus created soon passes away.†

The same explanation will apply to the action of electricity on all the mucous membranes—the eye, the ear, the pharynx, larynx, and urethra. Certainly the ultimate result of electrization is to give tone to the mucous membranes, as to other tissues of the body.

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* Diseases of the Eye. Translated by Drs. Hackley and Roosa, p. 26.

† Golubew has shown that the capillaries of the nictitating membrane of the frog contract transversely under the influence of powerful electrical shocks. (Billroth's Surgical Pathology. Translated by Dr. C. E. Hackley, p. 53.)

The treatment of rhinitis should usually be local. We have used both galvanization and faradization ; but have not usually depended on electricity for the completion of the cure. In some cases we have used electrical treatment so long as it appeared to be useful, and then commenced the alternate use of injections with the posterior nasal syringe. The most convenient and agreeable method of electrizing for rhinitis is to place the negative pole in the hand of the patient, and apply the positive over the bridge and sides of the nose, either with a stable or labile current. The current should be mild and the application not more than from three to five or ten minutes in duration. The hand is far better for application to the exterior of the nose than any artificial electrode that has yet been devised ; and as the current required is never strong, even those not accustomed to pass the current through their own persons will experience no difficulty. In a case of long standing and obstinate rhinitis which we completely and permanently cured, we used external galvanization of the nose in combination with local syringing with mild astringents.*

Anosmia, or Loss of Sense of Smell.—A very frequent result of long continued rhinitis is partial or complete anosmia. The acute form that appears in the early stages of severe cold usually passes away without treatment on the subsidence of the inflammation. In some cases anosmia is supposed to, amd probably does, result from careless and too prolonged use of over-irritating injections. There are various grades of the disease, from simple and scarcely perceptible obtuseness of the smell to absolute inability to detect any odor whatever. Kerosene, coffee, illuminating gas, make no more impression than substances of a negative character.

Anosmia may also result from central as well as peripheral lesion.

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* For full details of the method of treating rhinitis, see chapter on *Rhinitis* in Introduction to above quoted translation of Tobold.

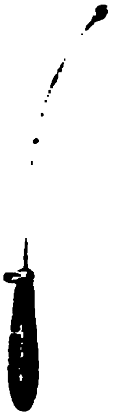

FIG. 8[illegible].—Nasal electrode.

The *treatment* of anosmia may be both external and internal. The external treatment is the same as that recommended for rhinitis, except that the current should be much stronger. The internal treatment consists in the direct application of a metallic electrode to the mucous membrane of the nasal passages. We have used for this purpose an insulated electrode, with a metallic bulbous extremity that can be run some distance up the inferior meatus. An insulated Eustachian catheter, containing a wire with a bulbous extremity, serves very well the purpose.

The *prognosis* of anosmia when it has arrived at the chronic stage is not, according to our present limited experience, very favorable. Our results have either been negative or partial—in no case complete.

Anosmia resulting from a fall—Improvement under treatment by local faradization.

CASE 153.—Mr. H. L., a medical student, aged 30, was referred to us by Dr. Roosa, May, 1870. Some six years previously the patient had fallen from a horse and sustained severe bruises about the head and face. From that time he had been unable to distinguish any odor with the exception of that of fresh ground coffee and kerosene oil.

A powerful application of the faradic current was made on either side of the bridge of the nose, near the eyes, enabling him in the course of a few hours to smell faintly certain strong perfumes.

On the following morning, however, he was surprised to find himself able to smell tobacco smoke, camphor, &c.

His sense of smell remained thus acute until three or four in the afternoon, when it suddenly disappeared.

A second application was followed by the beneficial result of the first, and with only a partial relapse, while the third and fourth séances rendered him sensible to most of the ordinary odors.

Rare and anomalous affection of the nose—Feeling of coldness.

CASE 154.—Mr. C——, a young man 23 years of age, referred to us in May, 1870, by Prof. John T. Metcalfe, presented very unusual symptoms. He represented that for some time he had been annoyed by a singular feeling of coldness in the nose, even in moderate weather. The sensation, he represented, was very much like that which is experienced in facing a biting wind on a cold day, though less in degree. Moreover, the nose was at all times abnormally and disagreeably greasy. In all other respects the health of the patient was excellent.

On the theory that perhaps these strange phenomena might be due to vasomotor disorder, we tried galvanization of the sympathetic as well as galvanization of the nose itself, but not sufficiently long to obtain any demonstrable result.

DISEASES OF THE HEART.

Palpitation of the Heart.—That galvanization of the sympathetic and general electrization have a positively accelerating or sedative effect on the action of the heart we have demonstrated by a large number of experiments. (See pp. 224 and 278.) This effect is produced by the action of the current on the sympathetic or the pneumogastric in the neck, in general electrization ; or it may also result, secondarily, from the influence that the system at large receives from the application.

Cases of functional disturbance of the heart, associated with dyspepsia and hysteria and anæmia, we have found to yield to general electrization in a large variety of instances, even when no special attention was directed to the sympathetic or the pneumogastric.

Fliess experimented with the constant galvanic current in 24 cases, 19 of which were functional, and 5 of an organic character.

All the cases were more or less relieved, even those dependent on structural lesion, while the majority of the functional cases were permanently cured.

His method of treatment was the daily application to the pneumogastric in the neck of mild, descending, galvanic currents, for one or two minutes. Temporary abatement of the symptoms followed each application.

The treatment of functional palpitation of the heart is certainly worthy of more attention than it has thus far received from electro-therapeutists.

Palpitation of the heart associated with dyspepsia—Unusual susceptibility to the current—Great improvement under general faradization.

CASE 155.—Mr. B——, of New Jersey, applied to us March 1st, 1867, with the symptoms of weakness of the stomach and liver, and also of functional derangement of the heart. He was tall, somewhat spare, but of fair muscular development. His occupation was that of a farmer, but for some time before he visited us he had been unable to make any protracted exertion. He had tested various kinds of internal medicines, and with unsatisfactory results.

During the first application he was momentarily overcome by a feeling of faintness, but at once rallied, and went away feeling stronger and brighter. He continued to visit us two or three times a week, for nearly two months. The improvement was slow, but very positive, with occasional temporary relapses. The cardiac symptoms gradually diminished, and his strength increased to such an extent that he was able to resume in part his daily avocation.

When he left us his digestive functions were well performed, and he had made arrangements to enter upon an active and pleasant out-door employment.

CHAPTER XXXVI.

MIDWIFERY.

THE use of electricity in midwifery was first recommended by Bertholon and Herder (1803). Kilian afterwards used "galvanic obstetrical forceps," made of two metals.* Faradic currents were first used for bringing on labor-pains by Hœniger, Zyly, and Jacoby, of Neustadt, in 1844. Since that time the same agent has been used for this purpose by Frank, Dempsey, Barnes, Mackenzie, Tyler Smith, Radford, and others.

The indication for the use of the current in midwifery is declared to be an adynamic condition of the uterus, when other conditions are favorable for or necessitate immediate delivery. Dempsey records a case where, after ergot in large doses had failed, faradization for forty minutes produced uterine contractions that resulted in the delivery of the child.

Frank reports a case of miscarriage, from a fall, in which faradization produced contractions of the uterus, and stopped the very profuse hemorrhage. Mackenzie succeeded in stopping the hemorrhage in two cases of placenta prævia. In one case the current was applied for six, and in the other for three hours.†

These observers claim that electricity acts more quickly, more uniformly, and with less injurious effects than ergot.‡

DISEASES OF THE MAMMARY GLAND—DEFICIENT LACTEAL SECRETION.

Secretion of milk may be increased by electrization. Two methods of faradization have been proposed, one by means of moist electrodes on the gland, the other by dry electrodes, with a view to excite the secretion of the gland by reflex action.

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* Meyer, op. cit., p. 452.

† Quoted by Meyer, op. cit., p. 452.

‡ Simpson and Scanzoni, on the other hand, deny the utility of electricity in midwifery.

Successful cases have been reported by Aubert and Becquerel.* Aubert cured one of his cases by dry, the other by moist electrodes. In the first case the patient had no milk three weeks after parturition. After a delay of seven months the treatment was applied. The third application brought on a milk-fever; after the fifth, milk appeared. In the other case the mother was attacked by pneumonia 11½ months after confinement. As a consequence the lacteal secretion ceased. Four faradizations with moist electrodes filled the breasts.

In Becquerel's case recovery was obtained by three applications. Similar results have been obtained by other observers.

Dr. Skinner, of Liverpool (quoted by Althaus), reports a case of a lady who, while nursing her fifth child, suffered complete suppression of the lacteal secretion, which the Dr. attributed to the tincture of iron that she was taking. He applied the current (probably the faradic, which, on account of its greater mechanical effects, would be more indicated in such cases) to the left breast. The patient felt a rush of milk to the breast, and in a few hours a full supply appeared.

The right breast had not been used for some time, on account of a previous abscess. As a new experiment, the Dr. made two applications of 5 minutes each to this breast, and brought on as much milk as in the other.

INTERMITTENT FEVER.

According to Tripier† the electric bath and statical electricity have been used in certain cases of intermittent fever, both in England and Sweden, and occasionally with satisfactory results. The efficacy of the preparation of quinine in malarial disease has, however, destroyed most of the interest that might otherwise have attached to electricity in its therapeutic relation to fevers.

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* Quoted by Meyer, op. cit., pp. 451 and 452.

† Manuel d'Électrothérapie, etc. 1861, p. 581.

In certain *chronic* conditions of intermittent fever, where quinine and other internal medication have proved unavailing as a means of permanent relief, we have seen undoubted benefit arise from *general* electrization. It undoubtedly acts in this case like any other stimulating tonic without any special influence on the malarial poison.

Intermittent fever—Temporary relief from quinine—Recovery under general faradization.

CASE 156.—Rev. Mr. L. applied to us for treatment in October, 1867. His general appearance presented all the marked characteristics of malarial influence, while he complained of obstinate constipation, loss of appetite, and a considerable degree of insomnia. One year previously he was prostrated by an attack of chills and fever, but soon recovered his usual health under the influence of quinine. In the following July he suffered another and more severe attack of the tertian, which soon changed into the quotidian type of the disease. During the first 10 days of his illness he took 100 grs. of quinine, but with little apparent benefit. Still further treatment by quinine interrupted the severity and regularity of the paroxysms, but by no means effected a cure. For some time before he fell under our observation (Oct. 14, '67), he suffered every few days from what is commonly termed "dumb ague." We immediately resorted to the most thorough form of treatment by general electrization with the faradic current. He was remarkably susceptible to its influence, and over the region of the stomach and liver especially only a very slight current could be borne.

This treatment was repeated every other day for two weeks. His bowels soon became regular, his appetite improved, and after the third application the attack ceased altogether. For several months, at least, after the cessation of treatment he continued free from any indications of returning symptoms. Subsequently he passed from under our observation.

A second and third case, in which the symptoms were less severe, but fully as persistent, yielded promptly and completely to the same method of treatment.

Intermittent fever associated with anæsthesia, insomnia, and great debility—Approximate recovery in two weeks by general faradization.

CASE 157.—Miss C. S., aged 23, was placed under our care by Dr. Geo. Steinert, of Harlem.

The patient had all her life been somewhat feeble in health, but at this time, and for a month previously, she had suffered from a very decided impairment in her general condition.

Every afternoon at 4 o'clock she experienced a very decided sense of chilliness, followed by a fever which lasted until 5 o'clock the following morning. The hands were at all hours exceedingly tremulous, and at night especially her fingers became quite anæsthetic. Her strength was so far exhausted that she could walk but a few blocks without great fatigue. Notwithstanding these unfavorable symptoms her bowels continued regular and her appetite good.

She suffered much, however, from insomnia, and was rarely able to sleep before 2 A.M.

A single general application of the faradic current resulted in marked relief of the condition of trembling and numbness. Her sleep rapidly improved ; the periodical chill and fever became less and less marked, and soon disappeared ; her strength decidedly increased, and 7 applications given during two weeks resulted in an approximate recovery.

NEUROSES FOLLOWING FEVERS.

Benedikt has treated neuroses, mostly paralysis, accompanying or following *scarlatina*, *peritonitis*, *the puerperal condition*, *erysipelas*, *diphtheria*, and *typhus* and *intermittent fever*.

CONVALESCENCE.

In slow convalescence from exhausting diseases of any kind general faradization is of excellent service, as we have demonstrated in a number of cases. In such conditions electrical treatment is to be recommended for its general tonic action. Dr. Burrall, of this city, informs us that he met with agreeable results from faradization in convalescence.

CHAPTER XXXVII.

ARTIFICIAL RESPIRATION BY ELECTRIZATION

IN CASES OF APPARENT DEATH FROM DROWNING OR SUFFOCATION THROUGH POISONOUS GASES, OR IN ASPHYXIA OF NEW-BORN INFANTS.

THE process of exciting artificial respiration by faradization* is as follows:—

1. *Let an assistant put the head, shoulders, and arms of the patient in a fixed position, while another stands ready to assist the expiratory movements by pressure.*
2. *Graduate the current to a strength sufficient to produce vigorous contractions of the muscles of the ball of the thumb, and then press the sponge electrodes (which should be of large size and well moistened) firmly over the phrenic nerves at the outer borders of the sterno-cleido-mastoid muscles and at the lower end of the scaleni muscles.* (See p. 255.)
3. *Interrupt the current (either by removing one of the electrodes, or by an interrupter), about three times a minute, while the assistant presses firmly on the abdomen, pausing occasionally to observe the effect.*
4. *If after a number of interruptions no inspiratory movements appear, increase the strength of the current.*

In some cases it is sufficient to put one electrode over the phrenic nerve and the other in the seventh intercostal space.

Large electrodes are used so as to affect the other muscles which have a share in inspiration (scalenus anticus and sterno-cleido-mastoid) simultaneously with the phrenic nerve. The object of holding the arms and shoulders in a fixed position is to prevent the interference which may arise from the contractions of the muscles of the arms, and at the same time to obtain the co-operation of the serratus and pectoral muscles.

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* The faradic current is usually employed for this purpose, although the interrupted galvanic current might answer the purpose.

Prof. Ziemssen, who first proposed this method of producing artificial respiration, advises the trial of the galvanic current in those cases where the irritability is lost to the faradic. The same writer presents a number of successful results in cases of poisoning by carbonic acid gas with this method of treatment from his own and other experience.*

In *opium poisoning* artificial respiration by faradization may be tried either alone or in connection with other methods. Dr. Iram has reported a case of opium poisoning, which recovered on the application of one pole to the neck and the other to the perinæum, after tannin, coffee, and tartar emetic had been unsuccessfully employed for several hours.

Those who attempt to produce artificial respiration in emergencies are frequently unfamiliar with the *motor point* (see p. 255) of the phrenic, and therefore apply the pole in the neck indiscriminately. A medical acquaintance informs us that an attempt of this kind which he made in a case of opium poisoning proved *instantaneously fatal to the patient.* Under ordinary methods the

Meyer records a successful result in a case of threatened death from exhaustion after diphtheria.*

Friedberg† succeeded in restoring a child of four years, asphyxiate by chloroform, by this method, combined with compression of the diaphragm.‡

Many failures have been made in the attempt to produce artificial respiration by faradization, because the operators were ignorant of the true method of application.

Resuscitation of New-born Children.—Successful experiments in the resuscitation of new-born children have been made by Schulz and Pernice. The latter succeeded in three out of five cases. In one of his cases the child was born to all appearance dead. Restoration was accomplished in half or three-quarters of an hour by the alternate use of the warm bath and faradization of the phrenic nerve.

Legros and Onimus‖ have experimented on animals—rats, dogs—with a view to bringing on resuscitation during syncope from loss of blood. They used the galvanic current, placing the negative pole in the mouth and the positive in the bowels.

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* Op. cit., p. 431.

† Quoted by Meyer, op. cit., pp. 431, 432.

‡ Irritation of the phrenic nerve might be readily combined with Howard's method of artificial respiration.

‖ Gaz. des Hôp., No. 53.

CHAPTER XXXVIII.

SOME DISEASES WHICH ARE OPEN TO ELECTRO-THERAPEUTICAL EXPERIMENT.

Diseases of the Lungs.—For diseases of the lungs electrization has accomplished less than in any other department. The recognized gravity of phthisis, together with the *à priori* improbability that it could be directly cured by any known methods of using electricity—these two causes have deterred electro-therapeutists from making even experimental applications to diseased lungs. One author—Bastings*, of Brussels—however, has reported most astounding results from faradization of the muscles of the chest. If we accept in good faith the statements of this author, even the second stages of phthisis may be cured by this method, which seems to affect the lungs not directly, but indirectly, through the muscular development which it causes, and the greater amount of oxygen which it enables the lungs to breathe.

The amazing statements which the author advances concerning the cure of consumption are entitled to more consideration than they would otherwise receive, from the fact that the fundamental idea on which his treatment is based. namely, that faradization of the muscles—electro-muscular gymnastics—markedly increases their size and strength, and also improves the general nutrition, is eminently sound and thoroughly demonstrable, as we have shown during all our investigations in electro-therapeutics. (See our chapter on the Effects of General Electrization, p. 230, also cases on pp. 299, 388, 399, 422, 432.

Bastings, however, used *localized* faradization of the muscles of the breast and arms. If the applications had been general, the tonic effects on the system would have been still more marked, since the brain, spinal cord, and sympathetic would also have been affected.

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* Die Lungenschwindsucht und ihre Heilung durch Electritcität. Translated from the French by Dr. Silbermann. Erlangen, 1866.

Vaust * has experimented with the method of Bastings—electro-muscular gymnastics—in growing children, who were not affected with any special diathesis, but who "*presented the appearance of debility, languor, and of lack of force so frequently found among the poorer classes.*"

The results were "wonderful." Not only were the muscles of the chest greatly increased in size after a number of applications, but their "breathing was deeper, their appetites better, and they were more cheerful and lively."

The writer gives the following tabulated list of cases, with the result of treatment six weeks on the muscles of the breast and arms :—

No.	Age.	Temperam't	Measure of chest before electrization, upper part, on a line with shoulders.	Measure of chest after treatment, upper part.	Measure of chest before electrization, upper part, on line with false ribs.	Measure of chest after electrization, lower part.	Measure of arm before electrization.	Measure of arm after electrization.
1	16	lymphatic.	65 centimes.	69 cent.	63 cent.	66 cent.	18 cent.	20 cent.
2	15½	"	68 "	70 "	65 "	68 "	17 "	20 "
3	10	scrofulous.	58 "	61 "	50 "	59 "	15 "	18 "
4	17	lymphatic.	67 "	71 "	65 "	67 "	19 "	21 "
5	12	"	60 "	63 "	59 "	61 "	15 "	17 "
6	13	"	63 "	65 "	60 "	62 "	17 "	19 "
7	15	"	63 "	65½ "	62 "	63 "	17 "	18 "
8	15	scrofulous.	62 "	64 "	60 "	61½ "	18 "	20 "

After six months' treatment the increase was still more marked in some of the cases. According to our experience, the growth of the muscles under faradization is at first quite rapid, but subsequently much slower, and in a few months becomes stationary. (See p. 220.)

Bastings has used these electro-muscular gymnastics in consumption, not with a *view to directly affect the tuberculous deposit at all, but, by strengthening the muscles of the chest, to so improve the respiratory power that more air can be inspired, and so benefit result to the healthy portion of the lung, and indirectly, through better oxygenation of the blood, to a certain extent on the diseased portion and on the whole system.*

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* Medicinisches Journal, vol. 38, Juni 1864, p. 599. Sitzung der Gesellschaft für Medicin und Naturwissenchaften zu Brüssel, vom 2. Mai 1864. This paper is presented in the work of Bastings, above quoted, p. 119 et seq

The statistics of Bastings are, to say the least, extraordinary. Of 37 cases that he treated, 25 recovered, 3 were improved, 6 died, and in 3 cases the residence of the patient was not known. Of these cases 9 suffered from hæmoptysis; of these 3 died and 6 lived. Of 6 who had cavities in their lungs, 3 died and 3 lived. Of 14 cases there was softening with sputa; in 17 the presence of tubercles without sputa was demonstrated by percussion and auscultation, and in 6 cases the presence of tubercles was suspected, but not proved.[*]

The method and principles of treatment in all these cases was substantially similar—electro-muscular gymnastics: about half a minute was given to each muscle, and about five minutes to each sitting. *Prolonged treatment was found to be injurious.*

The general statements of the author were confirmed by Dr. Bougard,[†] who affirms that the patients remain cured for one, two, or three years.

Dr. Crocq also speaks favorably of the method of Bastings, although in the treatment under his own direction of the very severe cases of consumption in the St. John Hospital he obtained no positive results.

Dr. Louis Elsberg, of this city, informs us that he has successfully used the method of Bastings in combination with that of Dr. H. G. Davis.[‡]

Although the beneficial effects of muscular exercise in consumption have long been conceded, yet, in the present state of the professional mind on the subject, the startling statistics of Bastings will need more numerous endorsements before they are fully accepted.

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[*] Op. cit., p. 107.

[†] Op. cit., p. 147. Loc. cit., p. 142 et seq.

[‡] Conservative Surgery, p. 186. This method of Dr. Davis consists in exercising the muscles of the arms and chest by swinging on a bar suspended from the ceiling.

Clearly, emphatically, and repeatedly, the history of electro-therapeutics has shown that science has lost far more by rejecting what is sound than by accepting what is absurd. There is scarcely any leading idea of the electro-therapeutists of the present day which has not at some time or other been a byword and reproach in the profession. For this reason, and for the *à priori* consideration that consumptives are usually more or less benefited by other tonic influences, among which electrization ranks the highest, the neglected and almost forgotten little work of Bastings should receive respectful attention.

We would suggest a method of treating pulmonary tuberculosis which, so far as we know, has not been used, but which is surely worthy of a trial. This method would consist in *galvanization of the diseased portion of the lung with a mild, stable current.*

This method could be conveniently carried out by placing one pole over the region of the chest, when accurate physical examination has discovered tuberculous deposit, and the other on the corresponding portion of the back.

The faradic current would hardly be as well indicated in this method, since by its mechanical effects it might cause hemorrhage, as it has been known to do in general faradization of tuberculous patients.*

Without considering the question of the nature of the tuberculous diathesis, there is no theoretical reason why the electric current might not cause the absorption of morbid deposits in the lung, just as it causes the absorption of various superficial tumors or serous effusions, or that it might promote the healing of ulcerous conditions there, just as it unquestionably promotes the healing of ulcerous conditions in other parts of the body.

In order that experiments on this point should be satisfactory it is necessary that the cases should be treated in their early stages; that, both before and after treatment, the condition of the lungs should be accurately tested by acknowledged authorities in that department, and finally that the patients should be kept under observation for months and years. We have already commenced a series of systematic and carefully recorded experiments in this direction, the results of which, whether favorable or the reverse, will, in proper time, be made public.

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* We called attention to this in our monograph on General Electrization, p. 59. In Bastings' method the current is not applied through the lungs, but only through the superficial muscles of the chest.

ASTHMA.

Asthma is one of the conditions for which it would be supposed, *à priori*, that electrization might be of service ; and yet the published records of successful treatment are not very extensive. One of the earliest if not the very earliest experimenters in this department was Dr. Wilson Philip, who began his researches in electricity in the early part of this century. "By transmitting its influence (galvanism) from the nape of the neck to the pit of the stomach, he gave decided relief in every one of twenty-two cases, of which four were in private practice, and eighteen in the Worcester infirmary. The power employed varied from ten to twenty-five pairs." * The treatment which is theoretically indicated is galvanization of the pneumogastric and sympathetic.

CHRONIC BRONCHITIS.

As an adjunct to hygienic and other medical treatment, general and localized faradization have sometimes appeared to be of considerable service. A very good way to affect the bronchial tubes is to place one of the electrodes just over the manubrium-sterni, while the other is applied to the coccyx or at the feet.

The subject of the electro-therapeutics of bronchitis has been but little investigated.

Dr. Garratt claims that in bronchitis positive results are obtained by the continuous wearing of his electric disks. They should be applied and worn in the same manner as for asthma.

We are now experimenting with asthma and chronic bronchitis, using chiefly the galvanic current.

DIABETES.

The supposed relation of this symptom to disease of the brain suggests the propriety of treating it by *galvanization of the sympathetic and of the brain and spinal cord.*

Dr. Wm. Dickinson,* who has made post-mortem examinations of the brain and spinal cord of five diabetic patients, found the following peculiar morbid changes, which were nearly similar in all:—

1. Dilatation of the arteries. This was the earliest symptom.
2. Degeneration of the nervous matter.
3. Cavities produced large enough to be seen without the microscope, and which contained products of nervous decay.
4. These contents become absorbed.

These changes were found near the arteries and throughout the spinal cord and encephalon, but especially in the medulla oblongata and pons varolii.†

These investigations were confirmed by a most distinguished authority in nervous pathology, Dr. Lockhart Clarke.

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* *Medical Times and Gazette*, March 19, 1870.

† The relation which has been established by Calvi between diabetes and pruritus of the vulva, which is a nervous affection, would seem also to speak for the nervous character of the former disease. (See Damon's Neuroses of the Skin. 1868, p. 25.)

Besides these pathological observations, there are two general considerations which might be adduced in favor of the theory that diabetes is essentially a nervous disease.

In the first place, it appears, in some instances at least, to be brought on by excessive mental excitement or worry. That it may be produced by concussion of the brain is, we believe, conceded. That there is a relation between diabetes and the base of the brain has for some time been more than suspected.

Secondly, the results of some of the therapeutical measures would seem at least to indicate that this disease may be favorably influenced through remedies that affect the nervous system. Prof. Austin Flint* has recently published reports of two or three cases of diabetes that were decidedly benefited by bromide of potassium.

Experience is the best and only test of the strength of these facts and considerations. The experiment of central galvanization —including the brain, spinal cord, and sympathetic—is surely worthy of a faithful trial, especially in the early stages of this affection. This treatment would be none the less indicated if, as some suppose, the pathological changes found in the brain and spinal cord of diabetic patients are merely the *result* of the disease.

Experimentally faradization of the liver might also be tried.

1. A very considerable proportion of diseases of the skin are of a more or less constitutional character. It might be that some of these could be benefited by general faradization and central galvanization.

2. Diseases of the skin, such as dermalgia, prurigo, urticaria, zoster, and anæsthesia—which are believed to be of a nervous character, or at least to be intimately related to the nervous system*—might also be treated by general faradization and central galvanization.

3. Those diseases that are believed to depend on irritation, or morbid condition of the vasa-motor nerves, might be treated by galvanization of the sympathetic.

4. Cutaneous lesions of a purely local character, and certain local manifestations of constitutional disorders, might be treated locally by faradization and galvanization.

We have already, in connection with Dr. Piffard, experimented on the principles here indicated, and with results that are most encouraging. In psoriasis of very long standing we have seen a decided improvement in the appearance of the spots after a few treatments with both poles of the galvanic current, and galvanization of the sympathetic. Prurigo also seems to yield to local galvanization. Dr. W. K. Brown, of Brooklyn, informs us that he succeeded in curing a case of prurigo by faradization. Lupus eczema, and all diseases of the skin, accompanied by ulceration, may be treated like ulcers in general. (See Ulcers.)

DISEASES OF THE KIDNEYS.

Very little scientific attention has been given to the electro-therapeutics of diseases of the kidneys, although the organs are sufficiently accessible to electrization. Most of the recognized chronic diseases of the kidneys are of so grave a character that they have offered but little encouragement for electrical experimentation.

It is impossible to pass an electric current through the body in the region of the kidneys without directly affecting these organs, as is clear from what is known of the conductibility of the tissues, and also from clinical observation. In many instances patients have called our attention to the fact that after general faradization the secretion of urine was much increased.

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* Vide Neuroses of the Skin, by Howard Damon, 1868.

DROPSY. ASCITES. ŒDEMA.

Dropsical effusions are susceptible of treatment by the electric currents, even when they depend on incurable diseases of the heart, liver, or kidneys. Galvanization and faradization may both be tried with strong currents.

Electrolysis is indicated in such cases, and it certainly demands a trial. In œdema of the lower limbs we have found both galvanization and faradization temporarily efficacious.

In case of ascites the patient passed, in the course of the following day, a very large amount of water, and the dropsical enlargement disappeared.

EXOPHTHALMIC GOITRE, OR GRAVES' DISEASE.

The characteristic features of this disease are enlargement of the thyroid gland, exophthalmus, and palpitation. It is due to disease of the sympathetic. It has been treated by galvanization of the sympathetic. Wietfeld* reports successes with this method of treatment.

INSOLATION (SUNSTROKE).

During seasons of protracted and excessive heat, such as has been notably experienced during the present summer (1870), a very large number of persons, especially in our cities, are more or less injured, either by the general depressing influence of the continued high temperature or by some special exposure, without being, in the ordinary sense of the word, *sunstruck*. Those whose nervous system has been exhausted or disordered by the excessive use of stimulants and narcotics, by debilitating diseases, and especially by over-labor or excitement of the brain, are most liable to be thus affected.

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* *Medical Times and Gazette*, Nov., 1868.

Injuries thus produced may be manifested by every variety of nervous disorder—spinal irritation, insomnia, neurasthenia, neuralgia, epilepsy, nervous dyspepsia, hysteria, paralysis, and not unlikely positive insanity.

The majority of such cases never know the exciting cause of their symptoms until, perhaps, it is indicated to them by the physician who inquires into them. In a number of our cases under the diseases above named the solar heat was a prominent if not a principal cause.

The symptoms may appear and reappear for months and years after the original attack. There is little doubt that there are through society thousands of such cases of various grades, many of whom have never suspected the nature of their malady. The solar origin of the symptoms which we have mentioned may be suspected not only when, as is very frequently the case, they can be traced to some definite exposure, but also when they are observed to be peculiar to the summer, remitting wholly or partially in winter, or to be especially aggravated by exposure to the sun, and to be experienced only during the daytime.

Besides the ordinary treatment of ice to the back of the head and neck, and internal tonics, such cases might well be treated by galvanization of the head, spine, and sympathetic, or by general faradization.

Dr. A. W. Catlin, of Brooklyn, has kindly communicated to us the details of a most unique and interesting case of paralysis of the arm following sunstroke, in a lad but three years old, that he has recently successfully treated by faradization :—

On the 20th of July, 1870, during the prevalence of the "heated term," a young boy, 3 years of age, was brought into the house quite prostrated by a sunstroke. The symptoms were, heat of skin, rapid pulse, delirium. Little was done for the patient until the third day, when "it was observed that the right arm hung powerless by the side." Dr. Catlin was then called in. He found, in addition, that *the pupil on the paralyzed side was much dilated.* The child was exceedingly irritable, and at times acted strangely. The right leg was unaffected.

Bromid. potass. and mustard pediluvia were prescribed, and the head was shaved. The head symptoms decidedly improved, and, after a week, the use of the bromid. potass. was suspended.

At this stage *the child was unable to raise the arm or flex the forearm, and had no grasping power of the hand.*

The first application was made on the 1st of August. August 6th the following record was made:—"Muscular power increasing; able to flex forearm upon the arm."

Symptoms of worms now appeared, and the ol. chenopodii brought away twelve or more ascarides.

The applications were continued every other day, with one interval of a week. Aug. 30 the following record was made:—"Motion almost entirely restored; can raise the arm above the head and flex the forearm; lacks confidence in moving it, and makes the motion slowly."

Taking all the facts of the above history into consideration—the age of the patient, the paralysis, the dilatation of the pupil on the same side as the paralysis (probably resulting from some involvement of the sympathetic), and the rapid and permanent recovery of the paralysis under faradization—the case becomes one of very exceptional interest.

ASTRAPHOBIA (FEAR OF LIGHTNING).

Some individuals, especially those of peculiarly impressible organizations, are not only unpleasantly but seriously affected during thunder-storms that are attended by vivid flashes of lightning. They suffer not only distressing fear, but positive pain in the head or stomach, that leaves them in a condition of exhaustion that may last several hours, or even two or three days.

A medical friend informed us of a patient under his care, who during thunder-storms was attacked by severe nausea, and by convulsive attacks resembling epilepsy. Under treatment directed to the improvement of her general system she greatly improved.

These symptoms, though most frequent with nervous people, and especially with women, may also appear in those who are otherwise strong both in health and will.

We once saw a typical case of this disease in a young man of about [illegible] years, who had the appearance of rather more than average vigor of constitution. He complained of no other symptom but during thunder-storms he was unhappy and greatly distressed, and suffered from exhaustion on the following day.

A mild galvanic current, applied to the head in such a manner as to cause flashes before the eyes, was exceedingly disagreeable to him, producing to a certain extent the same sensations as lightning itself.

This extreme and peculiar sensitiveness to lightning, to which we have given the name *astraphobia* (αστραπη, lightning, and φοβος, fear), is surely not physiological. It radically differs from mere timidity, and can hardly be explained in any other way than by supposing a peculiar morbid irritability of the central nervous system.

Central galvanization might be tried in this disease.

OZONE AND OZONIZED OXYGEN.

When sparks of electricity pass between two metallic plates, a peculiar odorous principle is developed, which has been termed *ozone* (from ὄζω, to smell). This odor is observed during experiments with apparatus for statical electricity, while the electricity is passing from a point, when a discharge from a strong battery is sent through a number of sheets of paper, and also after an object has been struck by lightning. As long ago as 1785, Von Marum observed that electrified oxygen gave forth an odor much like that which is observed after a lightning stroke. This odor was usually described as "sulphurous." M. Schönbein, who, in 1840, first called formal attention to ozone, first discovered that it appears at the positive pole in the electrolyzation of water.

The observer also found that this peculiar odoriferous principle can be preserved in glass vessels for a very long time. The odor may be prevented from appearing by raising the temperature of the liquid to a boiling point, and it may be at once neutralized by the addition of quite small quantities of pulverized charcoal, tin, zinc, iron, lead, antimony, bismuth, or arsenic, by a little mercury, or by introducing into the substance red-hot platinum or gold. It is produced by the slow oxidation of phosphorus. It is disengaged from solutions of a number of the salts, and from diluted nitric, phosphoric, and sulphuric acids.

Mr. Gann concluded, from his experiments, that this odor may be evolved from all metals, provided they are so treated as not to become oxidized or to combine with other metals.*

Tests. The test for ozone proposed by Schönbein was a paper moistened with a solution of iodide of potassium and starch. The ozone sets free the iodine and gives the starch a deep-blue color.

General Properties.—Ozone is active, intensified oxygen. Like oxygen, it has a powerful oxidizing action. It is about half as heavy as oxygen, and, at a temperature of 290° (Cent.) is changed back into ordinary oxygen. It is only soluble in oil of turpentine.

Ozone exists in the atmosphere in greater or less quantity, which is believed to vary with the atmospheric conditions, and to exert a definite and powerful influence on the health, although precise and satisfactory demonstration of the nature and extent of the laws of this influence is yet wanting.

According to the experiments of Prof. Schönbein, Messrs. Martigner, Marignac, De la Rive, Becquerel, Frémy, and others, it would appear that ozone is only a peculiar form of oxygen produced by electricity a change analogous to that which the solar rays bring forth in chlorine and that its presence in certain quantities is essential to health. According to Dr. Boeckel, Prof. Schönbein, and Dr. Billiard, the presence of cholera or malaria is attended by the absence of ozone.† It is probable that ozone has more or less share in the variations of the physical condition that have been ascribed to changes in the conditions of atmospheric electricity (see p. 93, et seq.). Ozone is found to be especially abundant in the atmosphere after a thunder-storm. It is also supposed to be produced by decay and the growth of plants. It destroys the impurities of the air miasms by producing oxidation. It has been estimated that "a volume of air containing $\frac{1}{8000}$ of ozone will purify 540 volumes of putrid air."

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* Lectures on Electricity by Henry M. Noad, London, 1844, p. 232.

† On the Influence of Variations of Electric Tension as the remote Cause of Epidemic and other Diseases. By Wm. Craig, 1864, p. 424.

In the arts ozone has been utilized for bleaching and disinfection.*

Therapeutic Properties.—Recently inhalations of ozonized oxygen have been utilized for therapeutics. The hygienic and sustaining influence of oxygen would seem to be decidedly increased and more or less changed in character when it becomes ozonized by the electric current. A convenient apparatus for the inhalation of ozonized oxygen is that of Siemen's, which consists of a glass tube lined with tin foil leaves that are connected with the current from a powerful helix, and slightly separated from each other, so that in passing from one to the other the current is interrupted with sparks. Through this tube the oxygen passes from an iron receiver, and ozone is developed by the action of the current at its interruptions. By this apparatus 15 per cent. of the oxygen may be converted into ozone. A glass apartment may be constructed on the same principle, in which the patient may sit for a long time and slowly breathe in a natural manner the diffused ozonized oxygen.

Dr. C. Lender,† of Berlin, has successfully experimented with the inhalation of ozonized oxygen in the treatment of wounds, and has found that in malaria and various conditions associated with impure blood and depraved nutrition, its corrective and tonic effects are very decided.

Antozone.—This, like ozone, is an active condition of oxygen, and is produced in the same way and at the same time. The fact that such a condition as *Antozone* might exist was suspected by Schönbein in 1858, and its properties have since been studied by Meissner in 1863 and 1869.

MAGNETIC MINERAL WATERS.

Attention has recently been called to the magnetic qualities of the water of some artesian wells at Eaton Rapids, Michigan. It was first observed that the metallic tools used in boring became magnetic and attracted iron. The water was found to possess the same magnetic power. A knife-blade suspended in the stream in a short time becomes a powerful magnet. A bar of steel in the form of a horseshoe, suspended in a vessel containing some of the water, becomes magnetic. A pocket compass dips its positive end when placed within ten feet of the well. The water has no peculiar taste or odor, but is very hard. Chemical analysis has found that there are from 8 to 110 grains of solid residue after evaporating a gallon of the water. This residue is variously composed of the carbonates of lime, magnesia, iron, soda, potassa, sulphate of lime, chloride of sodium, and carbonic acid.

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* Chemistry, Theoretical and Inorganic, by Prof. Geo. F. Barker, 1820, p. 125.

† Das unreine Blut und seine Reinigung durch negativ-electrischen Sauerstoff (Ozon). Also, Sauerstoff und Ozonsauerstoff, nebst ihrer Anwendung bei Verwundeten nach einem im Berliner Inhalatorium gehaltenen Votrage. Compare also Dr. A. H. Smith's excellent paper on Oxygen Gas as a Remedy in Disease. New York, 1870.

Medical properties.—The water is used both externally and internally, and, it is claimed, with positively beneficial results in a variety of morbid conditions.

ELECTRO-SURGERY.

ELECTRO-SURGERY.

Electro-surgery is that branch of electro-therapeutics which includes the electrical treatment of the diseases commonly known as surgical.

Besides the ordinary applications of electricity, all of which may be used for surgical diseases, it includes *galvano-cautery* and *electrolysis*, both of which may be regarded as peculiar to this department.

The principal surgical diseases and indications for which electricity in its various forms, and by its diverse methods of application, have been found of service, are:—

Aneurisms,
Varicose Veins,
Strictures,
Hydatids of the Liver,
Goitre,
Removal of Tumors,
Cauterization of Diseased Surfaces,
Killing Nerves,
Discussion of Tumors,
Ulcers,
Fistulæ and Sinuses,
Serous Effusions,
Orchitis,
Enlargement of the Prostate,
Sprains,
Spondylitis (Pott's Disease),
Pseudoarthrosis,
Hernia,
Morbus Coxarius,
Toothache,
Hemorrhoids,
Club Foot,
Exploration of Wounds,
Dissolution of Vesical Calculi,
Extraction of Foreign Bodies,
Removal of Poisonous Metals,
Local Anæsthesia.

HISTORY OF ELECTRO-SURGERY.

The history of electro-surgery, though to a considerable degree interwoven with the history of electro-therapeutics in general, is yet sufficiently distinct to entitle it to special consideration.

Electro-surgery was born in one of the darkest eras of electro-

[illegible]

[illegible] 1825,* when the [illegible]

[illegible]

The idea of causing coagulation of the blood by galvano-puncture was originally suggested by [illegible], and in 1831 [illegible] Pravaz and Leroy d'Etiolles proposed the treatment of aneurism by the method which was first practised by B. Phillips about the year 1832,‡ and afterwards studied by Liston.

In 1839 Schuster successfully employed electro-puncture for the treatment of hydrocele and other serous effusions, and in 1843 he reported his successes to the French Academy.

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* Two years previously (1823) Prévost and Dumas had attempted, with some success, the dissolution of calculi of the bladder in animals; and many years before some surgical diseases had been treated electrically, but the subject was not systematically studied until 1825.

† Mémoires sur l'électro-puncture, Paris, 1825.

‡ Erichsen's Surgery, p. 513.

In 1839 and the following year also Crussel, whose name is so prominent a figure in the history of electro-surgery, began his investigations on electrolysis.* His experiments excited little interest in the profession.

In 1843, also, Steinheil and Heider suggested the theory that the nerves of teeth might be killed by placing a platinum wire, heated by the passage of a galvanic current, in the cavity, and in 1845 Heider first successfully employed this method. He used for this purpose one very large element of Grove. The operation took but a few seconds.

In 1846, Crussel, whose name, as we have seen, is also to be remembered as the founder of electrolytic treatment, successfully removed by the heated platinum wire a "large fungus hemætodes, situated in the frontal and ocular region."

In the same year Petrequin, of Lyons, obtained successful results in the treatment of aneurisms by galvano-puncture. The year 1846 may therefore be regarded as one of special significance in the history of electro-surgery. About this time also the same treatment was used by Burci of Italy.

In 1847 Bertani and Milani first treated varicose veins by galvano-puncture. In the same year Crussel published his method of treating ulcers by availing himself of the electrolytic powers of the galvanic current. This author observed that when two metallic plates are connected with the poles of a galvanic apparatus, and applied to the body, very different effects were produced at the two poles—the positive acting like an acid, and making harder the tissue; the negative like an alkali, and causing an increase of fluid. On the strength of this observation Crussel treated ulcers and cancers by a flow connected with the positive pole of the apparatus, while the negative was in the hand of the patient. The result of this treatment was to cause a scab to form, which fell off, leaving the sore smaller and more healthful in appearance. Repeated treatment of this kind wrought cures.

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* Frommhold, Electrotherapie mit besonderer Rücksicht auf Nerven-Krankheiten, Pest, 1865, p. 104.

The first experiments with electrolysis were made much earlier than this; since, according to Brenner, Mongiardini and Lando had used a needle-shaped electrode, connected with the negative pole (probably of a voltaic pile, which was then just coming into notice), for the treatment of gangrene. *Dell' applicazione del Galvanismo alla medicina, Genovæ*, 1803.

In the same and the following year Crussel formally called the attention of the profession to "the electrolytic method of cure."* For the treatment of strictures another method was subsequently investigated by Willebrand, Wells, Ciniselli, and has recently been revised by Scouteten, Mallez, Tripier, and Althaus. In 1850 Marshall suggested and successfully employed the galvano-cautery in the treatment of fistulæ.

In 1852 Baumgarten and Wertheimer, with the co-operation of Malgaigne, successfully operated on an aggravated case of varicose veins in the arm.

In 1852, also, Ciniselli,† who still cultivates with distinguished success the department of electrolysis, first established by experiment that *the alkalies appear at the negative and the acids at the positive pole.* His method of demonstration was to lay a piece of flesh across the edges of two vessels filled with distilled water, and alternately connecting each of the vessels with a pole. The acids were found in the vessel containing the positive pole, and the alkalies in the vessel containing the negative. The piece of flesh was shrunken and burned.‡

In 1853 Ellis first used the heated platinum wire for cauterization of the cervix in inflammations and ulcerations. In this same year Hall successfully treated a case of ununited fracture by galvanopuncture.

A great and important impulse was given to galvano-cautery by Middeldorpf, who, in 1854, published his celebrated work on the subject.‖

In 1855, Demarquay removed a swelling of the submaxillary gland by galvano-puncture. In the same year Vergnés and Poey published their experiments on the removal of poisonous metals from the body by the electro-chemical bath.

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* Die Electrolytische Heilmethode. Neue Med.-Chir. Zeitung, 1847, No. 7. Med. Zeitung Russlands, 1847 and 1848. Quoted by Meyer, op cit., p. 474.

† Dell' azione chimica dell' electricita, Cremona, 1852.

‡ Brenner, Untersuchungen und Beobachtungen auf dem Gebiete der Elektrotherapie, Bd. ii., p. 265.

‖ The Galvano-caustic, Breslau, 1854.

In 1856, Boulu caused resolution of tumors in a number of cases by magneto-electricity, applied by means of metallic disks. Two cases of swelling of the parotid gland were in this way entirely cured. In the same year Meding extracted mercury from a patient who had long suffered from mercurial poisoning, by means of the electro-chemical bath.

In 1858 and 1859, Zsigmondi published the result of his successful experience with galvano-cautery after the system of Middeldorpf. In 1859, also, Delstanche, Lehmann, Burdel, and Thevissen reported successes in the treatment of hydrocele by *farado-puncture.*

In 1861 Braun and Von Gruenewald introduced the galvano-cautery into gynecology, where it has since been employed for the removal of polypi, excision of the cervix, and so forth.

Both in the extent and the variety of his operations in this department Middeldorpf far surpassed all his predecessors. He devised a powerful, though somewhat bulky apparatus, as well as various burners and loops for operating on different parts and organs of the body.

Galvano-cautery has been subsequently studied by various surgeons, and in different countries, and with success; but up to the present time the work of Middeldorpf is the leading systematic treatise that has yet appeared on the subject. Middeldorpf is, therefore, to galvano-cautery what Duchenne is to localized faradization, or Remak to central galvanization.

In 1867 Althaus* revived the attention of surgeons to the surgical powers of electricity, by reports of successful experiments in the treatment of nævi and tumors of various kinds by electrolyzation.

In the same year Mallez and Tripier published some very remarkable results in the treatment of strictures of the urethra, after the method originally proposed by Crussel.

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* Tumors and other Surgical Diseases. 1867.

In comparing this history of *surgical* with that of *medical* electricity, we observe a number of interesting points both of similarity and of contrast. Surgical is much younger than medical electricity, dating, as we have seen, from 1825. In neither department has the progress been uniform or consistent. Eras of extravagant expectation have been followed by eras of indifference, although with surgical electricity the contrast has been much less marked than with medical. The interest that was aroused by the introduction of electro-puncture in 1825, of electrolysis and galvano-cautery in 1846-47, was followed by a reaction of neglect that allowed the whole subject to sink into nearly absolute forgetfulness. The progress of surgical even more than of medical electricity has been impeded by want of convenient and reliable apparatus, and by this difficulty is explained the fact that so few workers have entered this most promising field. While the number of experimenters in medical electricity, both in the profession and out of it, and in various countries, is very large, including very many of the ablest writers of modern medical literature, the practice of distinctly surgical electricity has been confined to a few, and the authors by whom it has been really advanced could be counted on one's fingers.

Surgical, unlike medical electricity, has been studied and pursued mainly by men of science, and the progress that has been made in it has been much more frequently the direct result of scientific observation and experiment. Those physicians who have made eras in medical electricity have done so by improving, developing, and introducing to the profession methods of treatment which either by charlatans or others had been substantially known and practised before them.

Sarlandiere, Stenheil, Heider, and Crussel, on the contrary, first suggested and employed as well as introduced to the profession electro-puncture, galvano-cautery, and electrolysis.

Another important distinction is this, that nearly all the surgical diseases for which electricity is employed have been treated with more or less success by other methods, while in many of the medical diseases in which electrization has been most successful it has been the chief, and in some the only dependence.

Finally, it should not be forgotten that the surgical successes achieved by electricity have been of great service to electro-therapeutics in general. A surgical operation appeals to the eye and to mechanical skill, while medicine appeals more to the higher and rarer qualities of reason and imagination. Many who fail to comprehend a complex medical fact or principle may be fascinated and carried to enthusiasm by whatever strikes the senses. Hence we find that the suggestion of electro-puncture in 1825 revived an interest in electricity that its purely medical applications failed to sustain, and from that time to the present the fortunate operations of galvano-cautery and electrolysis have aroused the attention of many who had no faith in and no comprehension of the remarkable powers of electricity over nutrition.

GALVANO-CAUTERY.

Galvano-cautery is cauterization by a resisting wire heated by the galvanic current.

It is a law of electricity that when it passes through a resisting wire it raises its temperature in proportion to the resistance of the wire and the quantity of the electricity. *The wire thus heated is capable of producing cauterizing effects.* Platinum offers a greater resistance to the passage of the electric current than any other metal except mercury and lead, and is therefore used in galvano-cautery. It will be seen at once that the electricity is not applied to the body, as in the various forms of electrization, but only the wire heated by the passage of the current.

APPARATUS FOR GALVANO-CAUTERY.

For the purpose of galvano-cautery there is required a large *quantity* of electricity such as is generated by a *large surface* of metallic plates. Batteries for galvanization are constructed and united chiefly for *intensity;* batteries for galvano-cautery are constructed and united for *quantity* with sufficient intensity to overcome the resistance. Intensity is obtained by uniting a large number of cells of moderate size, in which the chemical action is comparatively feeble; quantity is obtained by uniting a small number of cells, 2, 4, or 6, of large size, and filled with powerful acid solution, so as to produce a great amount of chemical action. These elements may be united in such a way as to operate like one large element. (See p. 29.)

The apparatus for galvano-cauterization that is best known is that of Middeldorpf. This consists of a box, with two handles, divided into four parts, each of which contains a large element. The box is ten inches wide, twelve inches deep, and ten or eleven inches high.

The elements, which are composed of zinc and platinum, are six and a half inches high, and four and a half inches in diameter. They contain zinc cylinders which have altogether a surface of 312 square inches. Within these there are clay cells. Within these cells platinum is placed in the form of a star. The surface of the platinum in all the four elements is 250 square inches. It will be seen that the battery is that of Grove; it is filled with a solution of nitric and sulphuric acids.

Accompanying Apparatus.—The *connecting wires* for galvano-cautery should be very much larger than those for the ordinary galvanic or faradic current, since they have to conduct a much larger *quantity* of electricity. They are usually made of a number of strands of wire and are insulated by rubber.

The *handle* with which the loops are connected is made of wood. It is divided into halves, through each of which runs a gilded copper wire, one connecting with the positive, the other with the negative pole.

One of the wires is divided, so that it can be united by turning a screw when it is desired to complete the circuit. At the end of the handle the platinum wire is attached to both wires. As soon as the circuit is completed, by turning the screw of the handle, the platinum wire becomes hot, and can then be used for cautery.

This platinum wire may be of various shapes and sizes, according to the purpose required.

The form which is most used and best known is the *cutting loop*, for removing tumors, polypi, etc. This is made of flexible platinum wire, which may be of any size. On the handle is a wheel, by turning which the loop can be contracted as gradually as may be desired, in cutting off any tumor. *The instrument is* *placed in situ while cold. The circuit is completed by the screw, when the wire at once becomes heated, the loop is contracted in diameter by turning the wheel, and thus the tumor is burned off.*

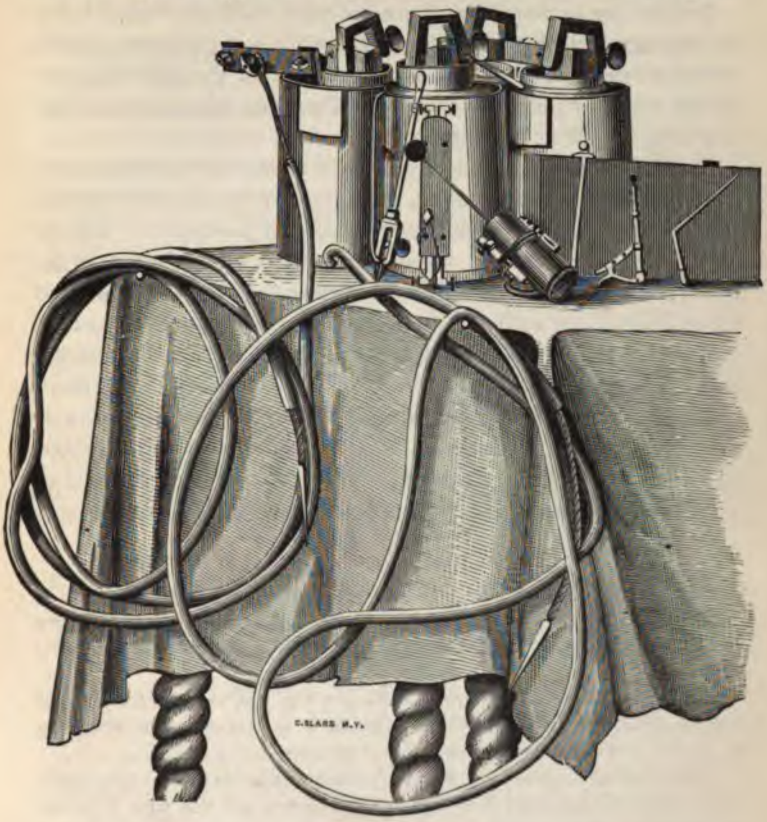

FIG. 90.—Middeldorpf's Apparatus for Galvano-cautery, with Reincke's Electrodes and Wire Loops.

On the table are represented the four large elements; in front of which are the electrodes of various shapes, containing the platinum loops for operating on the different cavities of the body.

The large connecting wires attached to the elements and suspended from the table are composed of a number of twisted wires and covered with rubber tubing.

The surgeon who has one of these handles can readily modify the shape of the wire for whatever special purpose may be desired.

Besides the cutting loop, there are used what are called burners or setons, which are simply platinum wires or platinum surfaces of various shapes and sizes. These are used for the same purposes as the actual or potential cautery. They may be connected with the same handle as the cutting loop.

Mr. Ellis* has devised a *porcelain cauterizer* which, when a large surface is to be acted on, must be very convenient. It consists of platinum wire coiled over a piece of porcelain. This is brought to a white heat when connected with the poles of the battery in the same manner as the cutting loop. Mr. Ellis used an ordinary silver catheter, straightened and slit up so as to contain the wire from the battery and the porcelain cauterizer at the end. With this instrument Mr. Ellis has cauterized the os uteri.

For the photograph from which the accompanying cut was prepared, and for the accompanying explanation we are indebted to the courtesy of Dr. Reincke :—The apparatus is composed of

" Glasses,	16 centimetres high,	11 cent.	in circumference.
Zinc cylinder,	15 " "	9 "	"
Clay vessel,	16 " "	7 "	"
Carbon plate,	18 " "	4, 5 cent. wide, and 2, 5 cent. thick.	

"The elements are joined together by twos; the two connecting wires, two metres long, consist of twisted copper wire, and are covered with an elastic tube.

"It is very convenient to have a handle (see Fig. 90), in which the different instruments are put in as needed. The handle is so arranged that by adding a pin the chain can be opened or closed at pleasure.

"*The Cutting Loop.*—1 mm. of thick platinum wire goes through two copper tubes, which are separated from each other by ivory, and this wire is wound over an ivory roller.

"As the heat in front at the end of the two copper pipes is very great, it is better to use in place of the ivory, at this part, an incombustible cement of equal parts of finely pulverized chalk and zinc oxyd.

"*Another instrument* is made of two copper rods, separated from each other by a small slit, in front of which platinum wire, shaped according to the different purposes required, can be fastened with screws. In the instrument shown by the illustration a ball of the just-described cement is pasted on a spiral-shaped piece of platina wire. In this way a red-hot iron is constantly at hand, to which any desired form can easily be given.

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* Althaus, op. cit., p. 333.

"Two other instruments are useful for removing polypi from the ear and larynx.*

"When used the clay vessels of the battery are filled with nitric acid, but the glasses with sulphuric acid diluted with water in the proportion of 1–10 parts. It is advisable to pour a little quicksilver into each glass, because thereby the zinc cylinder is well amalgamated. After having been used, the *clay vessels* and *coal* are put into clear water one or two days, and then left in the air to dry.

"All the parts connected together are to be well polished before being used, so that the electric current may not be hindered in its course."

But Middeldorpf's battery, though very powerful and reliable, is open to two very serious objections—it is both bulky and expensive.

There has been a great want of an apparatus for galvano-cautery which should be both portable and simple in its construction. This want is now beginning to be met.

Grenet has devised a combination of Bunsen's cells very strongly charged, but it is inconstant, requires much care, and an assistant is needed to agitate the liquid by blowing with a pair of bellows.

To keep the current of uniform strength, *Stöhrer* has arranged six pairs of Bunsen so that the metals can be lifted out of the liquid when not in use. The apparatus is quite powerful.

Foveaux has arranged four large Smee's elements, so that by turning a screw the metals can be raised out of the liquid when not in use. All these three forms of apparatus are more or less portable. They can, however, only be obtained by importation.

Moreover, no one of them entirely fulfils the conditions required in a galvano-cautery apparatus for general use.

By our suggestion Kidder has recently constructed a galvanic apparatus of 8 large Smee's elements, with a surface of about 400 square inches of platinized silver and of zinc. The apparatus is designed to meet the wants of those surgeons who cannot procure the bulky and expensive apparatus of Middeldorpf, and who desire also the advantages of compactness and portability.

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* An electric light for the larynx is also shown in the cut. The advantage of this is that the source of light moves with the instrument for operating.

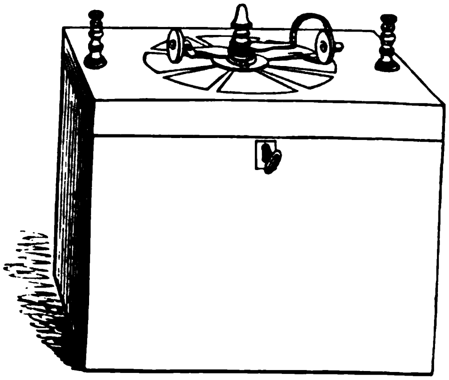

FIG. 91.—Kidder's Portable Apparatus for Galvano-cautery.

The wheel on the cover unites the elements for quantity without breaking the circuit. In this way the wire can be kept at any degree of heat which is deemed necessary to accomplish the object in hand. Thus the danger of breaking or melting of the wire through over-heating is avoided.* The connecting wires, handle, cutting loops, burners, etc., for this apparatus are the same in principle as for that of Middeldorpf.

USES OF THE GALVANO-CAUTERY.

The special purposes for which galvano-cautery has been recommended and employed are the following:—

1. *Removal of tumors* of various kinds, in parts that are not readily accessible to the ordinary methods of extirpation—pediculated tumors of the larynx, polypi of the larynx, naso-pharyngeal space, external auditory canal and uterus. Malignant tumors in any position may be removed by galvano-cautery in order to avoid hemorrhage.

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* A [illegible] for overcoming this difficulty was first devised by Fromm- [illegible]

2. *Cauterization of ulcers.*

3. *Cauterization of cancerous tumors* to stop the hemorrhage.

4. *Treatment of fistulæ*, by cauterizing the fistula alone, or by cauterizing surrounding parts, or by cauterizing both the opening and the parts surrounding, or by opening the fistula.

5. *Amputation of diseased organs or parts of organs* that are difficult of access—as the neck of the uterus, the tongue, etc.

6. *Treatment of neuralgia* by cauterizing, and so killing the nerve.

7. *Treatment of prolapsus uteri* by cauterizing with the *burners* the vaginal walls, and thus causing inflammation, suppuration, and cicatricial contraction.*

ADVANTAGES OF THE GALVANO-CAUTERY.

The advantages of the galvano-cautery over the actual and potential cautery and the ordinary operations by cutting instruments, are these :—

1. It can be used on parts that are not easily accessible to ordinary instruments.

2. It saves all hemorrhage.

3. It combines the after-cauterizing effect with the other results of the operation, as is sometimes desirable.

4. It is more sure in its action, and can be more accurately localized, especially in cavities, than the ordinary methods of cauterization.

5. It is but little painful after the operation, and is never dangerous.

The one *disadvantage* of the cautery is the difficulty of obtaining and managing the necessary apparatus.

This difficulty is now diminishing ; the advances that have recently been made in this department will bring the galvano-cautery within the reach of all who are willing to devote the amount of attention which a new department must at first demand.

There is reason to believe that in the future, with accessible and compact appliances, the use of the galvano-cautery will be greatly extended.

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* Meyer, op. cit., p. 464.

ELECTROLYSIS.

Electrolysis is the act or process of decomposing a compound substance by electricity.

Electro-chemical decomposition takes place at both poles, but with different products and manifestations, according to the nature of the substances acted upon, and the material of which the electrodes are composed.

If, for example, the two poles are introduced by needles into a blood-vessel, *acids* with albumen, fibrin, etc., appear at the positive, and *alkalies*, watery extracts, iron and coloring matter at the negative pole. When water is decomposed by the action of the current, *acids and oxygen* appear at the positive, and alkalies and hydrogen at the negative pole.

History of Electrolysis.—The chemical effects of *statical electricity* were first investigated by Drs. Priestley and Cavendish, in 1784. The decomposition of water by passing through it a succession of discharges of statical electricity was first discovered in 1780 by Messrs. Dieman, Paetz, Van Troostwyck, and Cuthbertson. The power of the *galvanic* current to decompose water was discovered and first described by Messrs. Nicholson and Carlisle, in 1800. They experimented with the voltaic pile, which had then just been discovered. These experimenters also decomposed other substances by the galvanic current. In Nov. 20, 1806, Sir Humphry Davy presented to the Royal Society a lecture "On some Chemical Agencies of Electricity," and in the following year he announced his discovery of the decomposition of the fixed alkalies. Between 1831 and 1840 Faraday published his "*Experimental Researches in Electricity*," in the most remarkable series of scientific essays that ever proceeded from the pen of man.

With the aid of two friends, Faraday prepared the following terminology of electrolysis, which is now generally adopted. The poles where the electricity passes in and out of the body that is undergoing decomposition are called *electrodes* (ἤλεκτρον, and ὁδός, way). The surface where the current enters the decomposing body is called the *anode* (ἀνα, upward, and ὁδός, way); the surface where the current leaves the decomposing body is called the *cathode* (κατὰ, downwards, and ὁδός, way). The *anode* is in contact with the *positive* pole, and the *cathode* with the negative.

Practically, anode is used as synonymous with positive pole, and cathode with negative, although, strictly speaking, anode and cathode refer to the *points of the decomposing body*, and positive and negative to the *poles of the battery* that are in contact with these.

Compound substances that are directly decomposable by the current are called *electrolytes* (ἤλεκτρον, and λύω, decompose). To *electrolyze* a body is to chemically decompose it by the current. The act of producing electrolysis is called *electrolyzation*.

The elements of an electrolyte are termed *iöns*, (εῖὼν, participle of the verb εῖμι, to go). Those *ions* that appear at the *anode* are termed *anions*, those which appear at the cathode are termed *cations*. Formerly anions were termed electro-negative, and cations the electro-positive elements of the compound. Water, for example, is an electrolyte that evolves two ions—oxygen and hydrogen ; oxygen goes to the anode and is the anion ; hydrogen goes to the cathode and is the cation.

The phenomena of electrolysis are due to a modification by the current of the chemical affinity of the particles through which its current passes, and which causes them to undergo decomposition and recomposition.

No substance can be an electrolyte which is not a conductor ; but in the readiness with which they are decomposed substances widely vary. Every electrolyte must contain more or less of water. Pure water, though an electrolyte, is yet decomposed only with great difficulty ; but by adding to it a little sulphuric acid, or certain salts, it very easily undergoes electrolysis. Other substances that are found to be ready electrolytes are chloride of sodium, muriatic acid, and iodide of potassium.

Although electrolysis, like all other phenomena connected with atomic changes, is but imperfectly understood, yet some of the general laws of its operation have been already well ascertained.

Among the more important of these laws are these :—

1. *Definite electro-chemical action.*—It has been found that when several substances are simultaneously decomposed by the current,

the elements that are evolved are definite in quantity and are electro-chemical equivalents to each other. This law, which was first discovered by Faraday,* can be well demonstrated by decomposing simultaneously protochloride of tin, chloride of lead, and water, when the tin, lead, chlorine, oxygen, and hydrogen which are evolved are *definite in quantity, and are electro-chemical equivalents of each other.* Faraday established the law that "the chemical power of a current of electricity is in direct proportion to the absolute quantity of electricity which passes," applied to all electrolytes.

2. *Primary and secondary results.*—The results of electrolytic action are distinguished as *primary and secondary.* The results are called primary when the elements that are decomposed appear at the electrodes unchanged and uncombined; the results are called secondary when the elements that are decomposed are changed or recombined when they appear at the electrodes. The secondary results are favored by the *nascent* condition of the elements that are decomposed. The secondary results are caused by the action of the decomposed elements on the substance of the electrode, or on the substance itself that is undergoing decomposition. Even the decomposition of water, when diluted with sulphuric acid, is really a secondary result. Water alone will not decompose, even when a powerful battery is used. If a few drops of sulphuric acid are added the gases are freely disengaged. The sulphuric acid, H_2SO_4, is disengaged by the current into H_2 at the negative and SO_4 at the positive pole; the former H_2 is liberated, and the latter SO_4 at the positive pole acts on the water and forms sulphuric acid again. Secondary decomposition is modified by the material of which each electrode is composed. Thus in decomposing sulphuric acid, when the positive electrode is made of carbon, the oxygen decomposed acts on the carbon, forming carbonic acid and carbonic oxide. Electro-chemical action continued for weeks, months, and years, as was done by that very laborious experimenter, Mr. Crosse, of Broomfield, may produce as secondary results interesting minerals, such as quartz, arragonite, malachite. During these experiments in electro-crystallization

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* Experimental Researches in Electricity, 3 vols., London, 1839, 1844, 1855.

Mr. Crosse discovered that remarkable insect, the ***acarus***, which appeared in electrized solutions of sulphate of iron, sulphate of zinc, and nitrate and sulphate of copper. It was supposed that the acari arose from ova deposited by insects floating in the atmosphere, and that they might possibly be hatched by electric action. As a reward for this discovery, which now seems to be almost forgotten, Mr. Crosse was subjected to absurd and outrageous abuse, as though he were infringing on the prerogatives of the Creator. Mr. Weekes, of Sandwich, in Kent, subsequently repeated the experiments of Crosse by passing electrical currents through silicate of potash in glass receivers over mercury. All possible care was taken to keep out foreign matter. After a constant action of a year, insects appeared, entirely similar to those obtained by Mr. Crosse. The metallic deposits in electro-metallizing are the secondary results of the electro-chemical decomposition. Water is electrolyzed, hydrogen is disengaged at the cathode, and oxygen at the anode; but the hydrogen reacts on the metallic solution, combines with its oxygen, and frees the metal. The oxygen also combines with an element at the anode.

3. *The different action of the poles.*—Different elements go to the anode and the cathode, according to the nature of the substance decomposed and the material of which the electrode is made.

Platinum wire makes the best electrode for electrolytic experiments on various substances, because platinum is not acted on. Copper and silver wire may be used, but the secondary action which they cause greatly complicates the experiment.

To distinguish the precise character of the changes that take place in the electrolysis of many substances is frequently difficult, and sometimes impossible. It is difficult to decide whether any of the elements of the electrolyte besides water undergoes decomposition; and whether the changes are of a primary or secondary character.

Among the substances that are most readily decomposed by the electric current are the following :—

Iodide of potassium.—This decomposes under a very feeble current, the iodide and oxygen going to the positive, and the hydrogen and alkali to the negative. The solution soon presents the color of iodine.

Chloride of sodium.—A solution of common salt decomposes quite readily, chlorine appearing at the positive and hydrogen and oxide of sodium at the negative pole.

Acetate of lead.—This salt in solution decomposes with comparative slowness by secondary action, peroxide of lead appearing at the positive pole, and hanging from it in light threads or masses. The water frequently decomposes before the lead yields at all.

Nitric acid.—*Strong* nitric acid conducts well and decomposes, oxygen appearing at the positive pole, nitrous acid and nitric oxyd at the negative pole. Dissolution takes place, and the water becomes yellow.

Nitrate of Potash.—This is a good conductor, and yields secondary results.

Sulphurous Acid.—This, when diluted, yields oxygen at the positive pole, and hydrogen and sulphur at the negative.

Sulphuric Acid.—This yields sulphur at the negative pole, and produces secondary results.

Muriatic Acid.—A strong solution of this yields hydrogen at the negative pole and chlorine at the positive pole.*

Besides these substances, we have experimented on a variety of fruits and vegetables—as lemons, apples, pears, etc., as well as on different kinds of meats, fat and lean, raw and cooked, and on fresh blood and the white of eggs. The effects of the electrolytic action, as they appear to the eye and the ear, though consistent with the great general laws of electrolysis of inorganic substances, yet are more or less modified by the varieties of structure. When a sound apple is electrolyzed, the part around the negative needle changes in color and looks as though it had been bruised and was beginning to decay, and the needle soon becomes loosened and will easily fall out. The process of drying and decoloration goes on after the operation is discontinued. In fruits and vegetables the electrolytic changes that take place are largely due to the electrolyzation of water, which is aided by the acids that they contain.

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* Acetic and Tartaric Acids are poor electrolytes.

When the white of an egg is electrolyzed by copper needles or wire, white flakes rapidly form around the needle connected with the negative pole, covering the needle as cotton covers a bobbin of a loom. This white covering soon becomes detached from the needle, if the current is tolerably strong, and floats on the surface of the albumen, and then another similar envelope is formed over the needle. In a little time the surface of the albumen, becomes covered with white, slight masses, resembling what are known on our tables as "floating islands." These formations are not coagula, as might be supposed, but are simply composed of hydrogen gas enveloped by very thin layers of albumen, into which it is mechanically driven by the electrolytic action, after the analogy of soap-bubbles and the froth of a beaten egg, where the distention is caused by common air enveloped by water and albumen.

Besides these changes the albumen becomes discolored, and reddish-yellow streaks are found at both poles. This discoloration is due partly to the action of the oxygen or the albumen on the copper of the electrodes, and partly, it may be supposed, to the decomposition of the albumen itself.

Although, as has been said, platinum wires at the point of insertion into the substance are best for these experiments, since they are not acted on, and exhibit the changes in their purity, yet a common sewing or darning needle, or copper wire, will answer; but it should be borne in mind that the action of the substances on these will complicate the observation, and that they will in a short time become destroyed by oxydization.

Electrolysis is not only a very important branch of electro-surgery, but, in its scientific and practical relations, as illustrated by the experiments above described, and in its application to disease, it is one of the most fascinating studies to which the human mind can be brought, and is therefore worthy of, and must everywhere receive, the systematic attention of the profession.

When now we come to inquire what relation these rich and varied phenomena of the electrolysis of inorganic substances sustains to the practical application of electrolysis to the treatment of disease, we are forced to admit that the subject is yet far short crumbles, until it resembles the burnt corners of a piece of roast beef. We have described the process in some detail because, in all the essential features, it represents what takes place during the electrolytic treatment of tumors, or indeed, of any diseased portion of the living body. For electrolysis, living as compared with dead tissue has the twofold advantage that its solutions are warmer and therefore better conductors, and that it is capable of the processes of absorption.

When, therefore, needles connected with the poles of a galvanic battery are inserted into a tumor, for example, a threefold action is produced.

1. *Decomposition of its fluid constituents.*—Hydrogen and alkalies, soda, potassa, etc., go to the negative, and oxygen and acids to the positive. The special character of these electrolytic phenomena will depend on the character of the tumor, and the rapidity of the action will be proportioned to the relative amount of its fluid constituent. As the body is mostly composed of water holding salts of potash, soda, etc., in solution, it is a good electrolyte, and in most of the conditions of disease undergoes rapid decomposition. Fatty tissue is slow to be electrolyzed, and requires great strength of the current, as we have frequently demonstrated on dead tissues, and therefore fatty tumors are quite difficult to discuss electrolytically. Scirrhus also requires considerable strength of current, and is electrolyzed with comparative slowness; the same is true of goitre and glandular tumors in general. Erectile tumors, which are almost entirely of fluid composition, can be electrolyzed very rapidly. Although electrolytic action takes place at both poles when inserted in tumors, as when inserted in inorganic substances, yet this action on the whole appears to be the most vigorous and most effective for causing absorption and disintegration at the negative pole, and in practice this pole is usually found to be the most efficacious, although successful results are obtained by the positive pole or by both combined. But, as has been shown, the electrolysis is modified both by the composition of the electrolyte and the character of the electrode, and it is not impossible that it may yet be practically established that some morbid conditions are better treated by the positive, and

others by the negative pole. There would indeed already appear to be some evidence that in scirrhus of the breast the negative pole is the most efficient, and that the positive, in some stages at least, may be actually injurious by causing suppuration.

The difficulty of settling this question arises, as has been suggested, from the fact that we know only in part the primary, and not at all the secondary changes that take place during the electrolysis of the living tissues. Reasoning from what we know of the electrolysis of inorganic substances, it is probable to assume that in the electrolysis of a malignant tumor, for example, the many chemical substances of which it is composed undergo manifold combinations and recombinations, the precise nature of which cannot well be fully divined, and the practical effect of which in causing discussion of the tumor can only be determined by extended clinical experience.

2. *Absorption.*—Absorption may be hastened both by the chemical changes that take place, and also by the mechanically irritating effect of the needles and the transference of the anions and cations. This absorption takes place both during and after the treatment. In some cases it is not at all observed during the operation, but goes on slowly for weeks following.

3. *Disintegration and atrophy.*—As a result of the decomposition and absorption, and associated with them, the tissues become dried, separated, shrivelled, and the tumor decreases in bulk and may entirely disappear. All these processes, or rather the effects of these processes, may be distinctly observed during the electrolysis of any small wen, mole, nævus, or wart, both during and after the operation. Shortly after the needle is inserted, the growth will be seen to change in color ; the skin soon begins to shrivel and contract, like an apple when it is baking. The next day the growth will be still smaller, and perhaps nearly or entirely obliterated.

The same phenomena may be observed during the electrolysis of large tumors, when, like erectile tumors, they are of soft consistence. Dense, hard growths, like scirrhus, exhibit these changes much more slowly, and during and immediately after the operation may show no other effect than perhaps a slight enlargement and softening, that are chiefly due to the disengaged gases. The other effects, absorption and disintegration, take place later and after repeated operations.

Although electrolysis is most effectually and most sensibly produced when the current is made very dense by being concentrated in small needles,* yet it is entirely demonstrable that electrolytic action takes place when, instead of needles, electrodes with a broad surface are used, though in a proportionally milder degree. This may be readily proved by substituting broad plates for needles in the decomposition of iodide of potassium, when the usual changes are seen to take place, though far less rapidly, provided the current is of sufficient strength to compensate for the decrease in density by the increase in the size of the electrodes.

It follows, therefore, that in all the ordinary applications of the galvanic current—the treatment of ulcers by metallic plates and external galvanization with moist sponges—*electrolytic* as well as electrotonic (see pp. 50, 156) effects are produced.

Althaus, who has specially studied "the action of the current upon the intimate structure of the skin and cellular tissue, muscular fibres and tendons, cartilages and bones, liver and pancreas, spleen and thyroid body, kidneys and supra-renal capsules, testicles, breasts, and ovaries," ascertained that "the electrolytic action of the negative pole on animal tissues was mainly composed of two different elements, viz.: of the mechanical action of the nascent hydrogen, which was under the microscope seen to rise in innummerable bubbles as soon as the circle was closed, and to force itself, as it were, between the structural elements of the tissues, driving their fibres mechanically asunder; and *secondly*, of the chemical action of the free alkali (soda and potassa), which, together with the hydrogen, is developed at the negative pole of the battery."†

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* Dr. Wollaston demonstrated, in 1801, that with a gold needle insulated to the point, which was but $\frac{1}{1500}$ of an inch in diameter, water could be sensibly decomposed by a succession of sparks of statical electricity only $\frac{1}{20}$ of an inch in length, while if the point of the needle was $\frac{1}{700}$ of an inch in diameter sparks $\frac{1}{8}$ of an inch in length were required in order to effect the same decomposition. (Noad's Lectures on Electricity, p. 76.)

† On the Electrolytic Treatment of Tumors and other Surgical Diseases, 1867, p. 10.

Althaus also found that the force and rapidity of these changes were, the structure being the same, in exact proportion to the electro-motive force employed. Ten cells had more effect than five cells, and twenty more than ten, and so on.

The number of elements being the same, tissues which contain the most water, as the muscles, cellular tissue, and spleen, yield most rapidly to the electrolytic action (see p. 84). Bones and teeth resist the action for a long time.

Althaus subsequently experimented on *living frogs and rabbits*, and found that the results were substantially the same as in the dead subject. He also ascertained that the negative pole, when applied by a needle to blood-vessels, caused disintegration of the blood. The result of this disintegration was that a foreign body appeared in the blood, around which lamellated fibrine was deposited. From all these experiments he concluded that the *negative pole was on the whole preferable for the treatment of aneurism.*

Apparatus for Electrolysis.—Electrolytic action is chiefly obtained by the *galvanic current*, although there is little question that the faradic current (both the electro-magnetic and magneto-electric) has more or less electrolytic power, and the magneto-electric current has been used in electro-plating.*

The magneto-electric rotary machine, as constructed by Saxton or Stöhrer, is capable of producing electrolysis.† It has, however, for this purpose, in therapeutics at least, no advantage, and decided disadvantages, as compared with the galvanic current.

It has been shown that for the purposes of galvano-cautery quantity with moderate intensity was required, and that this was obtained by a few large elements: for the purposes of electrolysis intensity with moderate or fair quantity is required, such as is obtained by a considerable number of elements of medium size.

Any of the galvanic batteries described in the chapter on apparatus (p. 131) can be used for electrolysis. The apparatus of Krüger and Hirschmann, of Stöhrer or of Kidder, can all produce this action.

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* Noad's Lectures, p. 402.

† See Frommhold's Electrotherapie mit besonderer Rücksicht auf Nerven-Krankheiten, Pest, 1865, p. 104.

Some of the uses of electrolysis, such as the discussion of malignant tumors, require more quantity of electricity than others. Any good combination of Daniell's or Bunsen's elements, or of Smee's elements of a good size, such as we use in our combination of 60 large cells, or of bisulphate of mercury or chloride of silver elements, if not too small, will furnish sufficient quantity for nearly any required purpose. The number of elements to be employed depends on the special purpose in hand. The general rule is, the larger and harder the extent of tissue to be acted on, the greater the quantity and intensity of electricity required. Deficiency of quantity or intensity in a battery may within certain limits be compensated by protracted application.

In the case of galvanic batteries for surgical as well as for medical purpose, it should always be borne in mind that the strength of the whole battery is considerably reduced by *weakening one of the cells*. This law of electricity, which is explained on the theory that the electric current can pass through any cell only by giving rise to approximately the same amount of decomposition that was necessary to generate it in the cells from which it came, we have demonstrated by reducing the strength of one of the elements of a battery, either by partially withdrawing the metals or by using less acid, or simple water, and comparing the current with that which is generated when all the elements are of nearly equal strength. It follows from this that the solution for batteries should be thoroughly made before it is poured into the cells, so that all the elements may be of uniform strength. To increase the strength of one or two cells without increasing the strength of all adds but little to the effective power of the battery.

Methods of testing batteries.—Batteries may be approximately tested with a view to ascertaining their comparative advantages for electrolysis by the amount of deflection they cause to the needle of the galvanometer (p. 31); by the rapidity and amount of decomposition which they cause in simple compounds, such as iodide of potassium, and by their capacity for heating platinum wire (p. 30).

The galvanometer indicates the approximate intensity and quantity of electricity in a battery. In the electrolytic treatment considerable quantity is required, for Faraday proved by experiment that to decompose a single grain of water there is needed a quantity sufficient to sustain a platinum wire $\frac{1}{104}$ of an inch in thickness red hot in contact with the air for three minutes and three-quarters.

But in the electrolytic treatment, not only is quantity required to cause decomposition, but very considerable intensity also, to overcome the resistance and make decomposition possible. A rough and but approximate test for both intensity and quantity—that is, for the qualities that are needed in electrolytic therapeutics—is found in the decomposition of iodide of potassium. The rapidity with which this yields to the current of a battery, and the amount of iodine evolved in a given time, very fairly indicates the capacity of that battery for electrolytic purposes. By this and by other chemical substances we have tested a variety of batteries of different construction, sizes, strength of solution, and number of elements, in order to see which might be regarded as best for electrolytic therapeutics. We have found that a given number of *large* Smee's elements produces greater decomposition than the same numbers of small Smee's elements, with the same strength of solution. We have found also that Stöhrer's zinc-carbon battery, when freshly charged, causes in a given time much more decomposition than the same number of Smee's elements of pretty nearly equal size, but that it quite rapidly weakens when it is much used. For electrolytic purposes, therefore, large elements are preferable to small, especially when hard tumors are to be treated; and if small cells are used, the applications must be more protracted. A series of small elements will cause as much decomposition in ten minutes as a series of twice their size will in five minutes, and when used in the treatment of tumors, for example, would need twice as much time as the large elements to accomplish the same result.* From this it follows that batteries composed of elements of pretty good size are best adapted for electrolysis. Small elements have no advantage except their portability, which in some cases, however, becomes an actual necessity.

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* In experimenting with galvanic batteries care must be taken to avoid frequent or long-continued connection of the *metallic* portions of the electrodes, since, on account of the feeble resistance thus offered—metals being far better conductors than the human body—powerful action takes place in the cells

Another advantage of large elements is that they last longer without cleaning than those which are very small, as all light, portable galvanic batteries must necessarily be.

Needles.—For producing electrolysis in tissues beneath the skin fine needles of gold or gilded steel are used. The advantage of the gold is that it resists oxidation better than any other metal. Gold or gilded needles can, however, be used only with the negative pole, since with the positive they would be acted on. The conductors may be composed of two, four, six, eight, or more needles. The needles may be insulated with hard rubber or collodion or shellac for about one-third of their length, so that when introduced into a tumor the skin may not be acted on and inflammation excited. Insulation, however, is not absolutely necessary.

Althaus has employed a *conductor*, a modification of which is represented in the following cut.

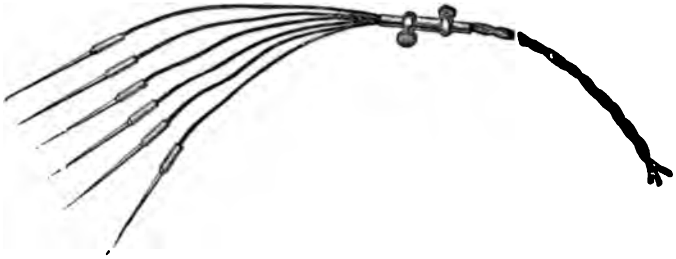

FIG. 92.—Conductor for Electrolysis.

This consists of a conducting wire, composed of a number of small wires twisted, with a number of branches, each one of which is so arranged that it can be attached to a gilded needle after it has been introduced into the part to be treated.

The advantages of this arrangement are that one needle or

(as is shown by the active evolution of gases, attended with a boiling or hissing sound), which, if allowed to continue, *eats holes in and rapidly consumes the zinc.*

[illegible] needles [illegible] be introduced at any desired [illegible]. In the instrument which we have had constructed, and which is represented in the cut, the needles are joined to the conducting wires by being inserted in insulated [illegible] of the [illegible] of the wire [illegible] makes the connection by [illegible].

General Method of Electrolysis.—Both poles may be made to operate simultaneously, or only the negative pole, as circumstances require. When only the negative pole is used, the circuit is completed by placing the positive, connected with an ordinary sponge electrode, on some indifferent point.

The introduction of the needles causes more or less pain, and for this reason it is advisable to resort to the production of local anæsthesia by ether spray, or to full anæsthetization. The pain produced by the action of the current is slight, except near the surface. The length of the séances ranges between 5 minutes and one hour, according to the battery used, the nature of the disease, and the result of treatment. It is best to begin, in the first operation, with a small number of cells and short séances.

Sometimes a number of séances are necessary; in other cases one is sufficient. *Intervals* of one, two, and three days, and even much longer, are required to secure the full after-effects of the treatment. It is needless to say that a *steady uninterrupted current* is required. Special suggestions will be offered under the different diseases.

Electrolysis is used for the following conditions:—

1. *Tumors of various kinds*, malignant and non-malignant, including nævi, *lipoma*, *goitre*, *scirrhus*, and *hydatids* of the liver.
2. *Aneurisms and varicose veins.*
3. *Serous effusions*: hydrocele, articular dropsy, etc.
4. *Strictures of the* urethra.
5. *Wounds and ulcers.*

DISEASES WHICH ARE TREATED BY ELECTROLYSIS—ANEURISMS.

The object in the galvanic treatment of aneurisms is not to rapidly induce coagulation of the blood, but to secure a gradual deposit of the layers of fibrin.

Dr. Althaus, as has been seen, contends that for this purpose the negative pole is by far preferable. It has been proved by experience that the clots which are rapidly formed are easily washed away, and may cause inflammation and gangrene. Only in exceptional cases is coagulation followed by permanent consolidation.

Although it is unquestionable that the negative pole, as Dr. Althaus contends, has a different electrolytic action from the positive, and although the evidences are accumulating that the negative pole produces more powerful and more satisfactory electrolytic effects in aneurisms than the positive, yet it is not yet established that in all cases the negative should be exclusively used. As will be seen, successful results have been obtained by the simultaneous use of both poles.

Method of Treatment.—The electrolytic treatment of aneurism requires from 5 to 20 cells. As the operation is somewhat painful, it is well to put the patient under the influence of an anæsthetic, or to use local anæsthesia. It is not well to begin with the full power of the current, but to introduce the needle with but one or two elements, and to gradually increase the number until the desired number is reached. When this caution is used, merely local anæsthesia will sometimes be sufficient.

Two or three needles connected with the negative pole (see p. 627) should be introduced into the aneurism, while a sponge electrode connected with the positive pole is applied to the surface near by. The length of the application may range between 5 and 45 minutes. From one to four or five operations are usually sufficient. Some important cures have, however, been obtained by coagulating the blood with the positive pole, or with both poles.

Ciniselli reports a cure of aneurism of the ascending aorta by galvano-puncture. The tumor appeared in the third intercostal space. He first introduced one needle connected with the positive pole into the tumor, and connected the negative pole with a sponge electrode that was applied outside, near the tumor.

He next united the positive pole with the second needle, and the negative to the needle that was first connected with the positive pole. The séance was protracted 40 minutes. Sixty-six days after the operation the patient was well, although at first the operation was followed by symptoms of superficial inflammation.

Meyer has recorded a cure of aneurism of the left knee by three needles connected with the positive pole with 20 cells. A small abscess appeared near the patella, but it was promptly cured.

Eyre has reported a case of aneurism of the left external iliac artery by *farado*-puncture. Symptoms of imflammation appeared, but after 17 days the tumor was firmer, and evinced less pulsation. The faradic current, however, has nothing to commend it for the treatment of aneurism.

Duncan has succeeded in curing two cases of aneurism by the electrolytic method without any untoward event.

Cimselli successfully treated an aneurism of the ascending aorta in a patient 46 years of age, by galvano-puncture. Three needles, connected with a voltaic pile of thirty pairs, were inserted in the third intercostal space where the tumor was prominent and the pulsation strong. The operation lasted forty minutes. After the operation the skin over the tumor was red. For three weeks have resulted from a fall, was very large, occupying most of the lateral triangle of the neck, and extending beneath the sterno-cleido-mastoid muscle to the median line. An operation was not deemed advisable. Digital compression was tried for 26 hours. This treatment caused no change in the appearance of the aneurism, but an ulcer, followed by spreading gangrene, appeared. The sac consequently became exposed. Treatment by carbolic acid and bromine arrested the sloughing, leaving a deep ulcer about 2 inches in diameter.

"The sore gradually contracted, but never entirely healed, up to the time of the patient's death. The inflammation which attended the sloughing process seemed to have produced some consolidation of the sac and its contents at its lower part, and on the 7th of May the pulsation disappeared in the right radial and ulnar arteries, and did not return. The upper and inner portion of the aneurism, however, continued to pulsate as before, and the tumor was evidently increasing in size. Under these circumstances I decided to resort to galvano-puncture, and obtained the assistance of my friend Dr. Guleke, who kindly loaned his apparatus for the operation, which he performed on May 15th. A gilded steel needle was introduced into the sac at its upper part, and was then connected with the positive electrode, the negative electrode being applied to the skin over the upper part of the sternum. The current was applied for a quarter of an hour, the patient having been previously put under the influence of sulphuric ether. No bad effects followed the operation, which was repeated in the same manner by Dr. Guleke, May 22d, and by myself on May 26th. Notwithstanding the tumor became firmer after these operations, it enlarged so rapidly that I yielded to the patient's request, and abstained from further surgical treatment. The suffering produced by the pressure of the growing aneurism on the œsophagus, trachea, and the neighboring nerves was most intense, and could be only partially controlled by large doses of morphine, frequently repeated. On the 8th of June the neck measured 22 inches in circumference. On the 9th the aneurism burst externally, and a copious hemorrhage followed: the hemorrhage recurred on June 12th, and proved fatal. The rupture took place through the ulcer above mentioned."

Aneurism of the Brachial Artery.

A patient of Petrequin, 29 years of age, suffered from an aneurism of the bend of the elbow, resulting from a wound of the brachial artery. Four steel needles connected with a pile of 45 elements were introduced into the tumor, two on the outer and two on the inner side. At first the negative pole was connected with upper and outer needles, and the positive with the upper and inner needles. After three minutes the negative pole was connected with the lower and outer needles, and, after three minutes more, the positive pole was connected with the inner and lower needles. This part of the operation lasted twelve minutes, during the last three of which the negative pole was again connected with the upper and inner needles. The tumor was now found to be harder in the lower than the upper portion, and the operation was continued for some time through the upper needles. During the operation an assistant compressed the brachial artery. The patient suffered much after the needles were removed, and cold water was applied to the arm and a compress over the brachial artery for three days. Some ulceration took place. Both in the radial and ulnar arteries pulsation soon appeared.

In twenty-eight days from the date of the operation the aneurism had disappeared.*

The electrolytic treatment is especially indicated in aneurism of the innominata, iliac, and subclavian arteries, where other measures are not usually attempted.

Nicolli was successful in two cases of aneurisms of the aorta, and Petrequin in three cases of aneurism of the subclavian.

VARICOSE VEINS.

Bertani and Milani experimented in the treatment of varicose veins by galvano-puncture as far back as 1847. These observers applied a bandage or tourniquet to the limb to diminish the blood supply before operating.

Baumgarten and Wertheimer successfully treated a severe case of varicose veins of the upper extremity up to acromion, whence the evil seemed to spread over the trunk. The patient was a young girl. The limb had doubled in size.

> "Baumgarten and Wertheimer introduced in three sittings, at an interval of two to three days each time, about ten needles into the most extended veins, placing a conductor connected with the negative pole in the hand of the patient, at the same time connecting all the needles with the positive pole. The operation caused but little pain. After a few minutes the needles were removed, when, in place of the dilated veins, full resistant cords were felt, a sure sign of complete coagulation. After a month, the greater portion of the veins was obliterated, and the volume of the limb considerably reduced; only then those veins, heretofore of normal size, began to dilate a little, which circumstance can exercise no influence on our opinion of this *modus operandi*."†

The interesting point in the above case was that the coagulation was produced by the *positive pole*.

These observers concluded, from their experiments on animals, that the negative pole produced no coagulation of blood-vessels; that both poles produced a slow and feeble coagulation; but that the most rapid and complete coagulation was produced by the positive pole.

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* Hamilton's Prize Essay, p. 25.

† Meyer, op. cit., p. 471.

It will be seen that these conclusions are opposed to those which Althaus obtained by his more recent investigations. (See p. 639.)

STRICTURES OF THE URETHRA.

Electrolysis for strictures was first used by Crussel. The same treatment was subsequently employed by Willebrand and Wertheimer.

The method of Willebrand was to introduce to the stricture a metallic sound, insulated up to the tip, and to connect this with the negative pole, while the positive was held in the hand of the patient. The application was continued for ten or twenty minutes, and the cure was accomplished in eight or ten days.

The first important and successful results in the electrolytic treatment of strictures of urethra were obtained by Mallez and Tripier, in 1867.*

Their method of treatment was to introduce an insulated sound with a metallic extremity to the seat of the stricture, connecting it with the negative pole, while the positive was applied to the inner side of the thigh by a moistened sponge electrode. They used a bisulphate of mercury battery.

At the commencement of the operation the patient feels a pricking sensation. This sensation becomes less and less marked. The metallic extremity is then passed along until all parts of the stricture are affected. After the operation a catheter can be introduced without difficulty.

The operation lasts about five minutes; from one to five applications are necessary. In the majority of the thirty-one cases treated by Mallez and Tripier, one application was sufficient.

The diameter of the urethra seems to increase slightly for a few days succeeding the operation.

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* De la guérison durable des rétrécissements de l'urèthre, par la galvanocaustique chimique, Paris, 1867. The term "*chemical galvano-cautery,*" used by these authors, is synonymous with *electrolysis*.

The pain of the operation is usually very slight: in one case only was it severe. In a minority of the cases slight hemorrhage appeared.

In one case fever appeared, and the patient died a week after the operation, although the operation itself was successful. Mallez and Tripier assert that the one fatal case should not be allowed to weigh as evidence against the method of treatment, because death has also occurred from the mere passing of the catheter in patients who were in a condition of great debility.

The following cases are taken from the monograph of Mallez and Tripier :—

"Q., 40 years old; policeman. Two attacks of gonorrhœa. Urination frequent, difficult, and painful.

"Fibrous stricture at the union of the bulb and of the membranous portion, admitting only with difficulty a No. 3 bougie. Urine very catarrhal. No previous treatment.

"June 2, 1864. Séance of electrolysis for four minutes with a battery of 12 elements of bisulphate of mercury freshly charged. Passage of bougies Nos. 14 and 16.

"June 8. Second séance of electrolysis for four minutes. Passage of bougie No. 21. Seen four times in five days; same condition June 15th, 1866. The cure has remained complete."

"M., 57 years old; retired soldier. An attack of gonorrhœa at 25 years; difficulty of urination for 8 years.

"August, 1864. There was found to be a fibrous stricture, 10 centimetres from the meatus. The stricture, which was 1 centimetre in length, made the passage of a No. 6 bougie very difficult.

"September 5. Séances of electrolysis for 15 minutes with a battery of 12 small elements of bisulphate of mercury. Bougies Nos. 15, 16, and 17 passed immediately. Very light hemorrhage. Subsequent dilatation for a month with bougies anointed with belladonna. The patient is the only one of those on whom we have operated who has been submitted to subsequent treatment. Seen again July 25, 1865. Bougies Nos. 18 and 20 passed easily."

"D., aged 39; jeweller. Two attacks of gonorrhœa. Difficulty of urinating for 8 years.

"Sept. 8, 1866. Fibrous stricture was diagnosticated 8 centimetres from the meatus. Bougie No. 6 is introduced, but with difficulty. Frequent desire to urinate; urine mucous; mild cystitis.

"Sept. 27, 1866. Bougie No. 8 can be introduced; it is strongly retained. Séance of electrolysis of seven minutes. Immediate benefit from the operation was not noted.

"November 22. Bougie No. 22 passed freely."

"P., aged 22, waiter in a café. Two attacks of gonorrhœa. Annular fibrous stricture, 7 centimetres from the meatus.

"June, 1866. Difficult introduction of a No. 6 bougie. Treatment for five days by dilatation.

"Attacked with two relapses of retention of urine. Entered the Hospital Lariboissiere, where he submitted each time to some séances of dilatation.

"Reappeared at the Dispensary December 15, 1866. Bougie No. 9 passed, but is retained. We see him no more until February 25, 1867. March 1, the bougie is no longer retained. Séance of electrolysis for 10 minutes. A bougie No. 20 is introduced without difficulty.

"March 22. Returns on account of an attack of gonorrhœa. An injection of subnitrate of bismuth was prescribed. April 2, the gonorrhœa has disappeared. The calibre of the urethra is maintained."

The following case terminated fatally. In regard to the nature of the fever, and its relation to the treatment, each person can decide for himself from the history :—

"D., aged 43 years; tailor. Three attacks of gonorrhœa, one of which had lasted for four years. Difficulty of urinating more and more marked. During various relapses he had recourse to catheterism, which had brought on an attack of fever, and made it necessary to resort to leeches, cataplasms, baths, and various diuretics.

"November, 1863. Constitution shattered. Urinary jet small, intermittent, and misshapen. Urination demands violent efforts. Hard, callous stricture, 8 centimetres from the meatus, arresting bougie No. 5. A search of a quarter of an hour is necessary to find the orifice. Only after half an hour is it possible to introduce a bougie No. 3, which gives to the hand a sensation of contact with a horny surface. Slight flow of blood. *Access of fever in the evening.*

"Three days afterward, new introduction of bougie No. 3. Access of fever in the evening.

"Four days later, introduction of bougie No. 4. Mild access of fever.

"Feb. 3, 1864. Introduction of bougie No. 3.

"Feb. 7. Urethrotomy internal. Division of the strictured part required considerable effort. Quite severe fever for four days.

"The patient left Paris.

"July 25, he returned, complaining of a very sensible diminution of the [illegible] of the [illegible] etc. The features that appeared were hardness, and resistance offered anteriorly by the stricture.

"August 2. Seance of electrolysis of five minutes. Bougie No. 17 passed freely. No flow of blood. Before leaving the patient urinated easily and without pain. He was sent to take a bath. Mild fever in the evening. The day following the fever was stronger. On the sixth day the patient died, after a fourth [illegible] attack, notwithstanding the use of sulphate of quinine in large doses. Resort was also had to the application of leeches."

Brenner* has also experimented with the electrolytic treatment of strictures of the urethra, and has confirmed the observations of Mallez and Tripier. He reports thirteen cases. He agrees with them that the operation is far preferable to urethrotomy. The following is one of Brenner's cases: †

"J., a servant, 30 years old, spare and miserable. He had in 1854 a second and last attack of gonorrhœa, and suffered continually from a slight discharge, sometimes mucous, sometimes purulent. For two years he had remarked that the urinary stream had become much smaller and weaker than usual.

"With great difficulty an elastic bougie was introduced through a stricture at the bulb. The endoscope showed at this place a whitish color of the mucous membrane of the anterior wall, which formed bad folds and incompletely closed the canal. The posterior was in a quite normal condition: the folds are regular, though somewhat thick: the color is less red than normal: the papillæ are somewhat developed: the epithelium was rubbed off (chronic papillary urethritis). March 22, 1868, cauterization for twelve minutes with twelve Marié-Davy's elements. The electrode passed the stricture very slowly and gradually. Considerable hemorrhage. Injections of tannin.

"March 27. The patient has had severe fever from March 23d until yesterday. The hemorrhage was of importance only for two hours: from the first injection to March 24th no blood appeared. Elastic bougies as high as No. 12 easily pressed through.

"March 29. The metallic bougie No. 17 was introduced with great ease, with little pain, and little hemorrhage.

"April 3. The patient urinated well; has no hemorrhage, and is generally well. Cauterization repeated as before, with electrode No. 16, which in five minutes overcame the stricture. No hemorrhage. The elastic bougie No. 20 is passed through very easily, without pain and without irritation. Considerable hemorrhage. Injection of tannin.

"April 15. The button-shaped bougie No. 16 struck upon the remains of the stricture. The metallic bougie No. 20 was afterwards squeezed in, not without difficulty and some pain. Nevertheless no hemorrhage followed. The patient was directed to introduce himself the elastic bougie No. 20."

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* Untersuchungen etc., Bd. ii., 4 Abth., p. 269 et seq.

† Loc. cit., p. 271.

Another still more satisfactory case was the following :—

"T., aged 36; professor; has suffered 13 years before from an attack of gonorrhœa. From that time there has been a constant and slightly purulent discharge from the urethra. Six years previously there was retention of the urine; this was relieved by the introduction of bougies.

"August 14, 1868, he appeared at Marion Hospital; the evening before he had drunk several glasses of punch. For 14 hours he was unable to urinate. Three physicians had already attempted to pass the sound without succeeding in getting beyond the bulb; as a result violent hemorrhage had appeared. Near the bulb, on the anterior wall, a false passage appeared. A stricture on the bulb was finally overcome by rotating bougie No. 3.

"During the manipulations the patient passed three ounces of urine, while the bougie remained in position. At 3 o'clock I succeeded in introducing the elastic catheter No. 6. This remained in position.

"August 15, I removed the catheter and substituted a bougie No. 6, which was allowed to remain in one hour.

"Evening. Urine appears in small drops. The elastic catheter No. 6 was again introduced and allowed to remain.

"August 16. The catheter was removed, and cauterization (electrolysis), with ten Marié-Davy's elements, was employed for twenty minutes, filled with a weak solution. The patient experienced no more sensation than when the simple bougie was introduced. A turbid fluid, without blood, was discharged from the canal. The elastic bougie No. 16 was readily passed and was not held.

"August 17. Good condition. Urine flows in strong jets. The elastic bougie No. 18 does not pass the *fossa navicularis*. No. 17 causes a little pain in the stricture. No. 16 passes with great ease. I saw the patient a week later. He succeeded in introducing the elastic bougie No. 17 with ease, and he was directed to continue the procedure."

In most of the thirteen cases of Brenner* the pain of the operation was slight; in three cases there was no pain.

Some *pain* was felt at the point where the positive sponge electrode was applied to the thigh; but this could be at once relieved by shifting its position from time to time. The stable application of the galvanic current of much strength always caused pain.

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* Loc. cit., p. 280 et seq.

Hemorrhage easily appeared when either the cathode connected with the battery or a simple bougie was forced through. Only in two cases was there *hemorrhage* when no force was used. The hemorrhage could be stopped by astringent injections.

Fever appeared only in two cases. Febrile symptoms were probably caused by the presence of the foreign body in the urethra more than by the electrolytic effect of the current.

Pain in urination was observed in three cases for several days after cauterization. In one of these cases the operation itself was painless.

Perineal abscesses appeared in two cases. These were probably caused by the treatment, although they might have resulted from simple catheterization without any current. *Death* resulted in one case that was suffering from previous urethro-scrotal fistula. Autopsy showed that the electrolytic treatment was not the only cause of death, though it might have hastened it.

SPASMODIC STRICTURE.

This condition may be relieved by the faradic current, which electrolysis. Althaus suggests that the œsophageal electrode should be applied to the seat of the stricture and connected with a negative pole, while the positive is applied to the neck or back. From fifteen to thirty cells would probably be required.

HYDATIDS OF THE LIVER.

Durham and Forster* have treated eight hydatid tumors of the liver with success by electrolysis at Guy's Hospital and the Royal Infirmary for Children, Waterloo Road.

"In one patient, who was under the care of Dr. Hilton Fagge, and who was operated upon by Mr. Durham in June, 1868, the dulness in the hepatic region measured seven inches vertically, the ribs on that side were bulged, and the intercostal spaces prominent. Two needles were introduced into the most prominent part of the swelling, one piercing the space between the eighth and ninth costal cartilages, and the other about two inches behind it, between the ninth and tenth ribs. The needles passed in to a depth of two or three inches. One of them was evidently free in the fluid, for it could be moved about and rubbed against the other. The posterior needle doubtless passed through the diaphragm, as it was jerked about by the respiratory movements. Both needles were connected with the negative pole of ten cells of the battery, freshly charged. The positive pole, connected with a moistened conductor, was placed between and near the needles. The current was allowed to pass for twenty-five minutes, and during this time there was a crackling feeling under the finger as of emphysema, owing to the development of hydrogen from the liquid of the cyst. After the operation there was some pain for four or five hours. In the evening the temperature was 100.9°, and the patient did not sleep well that night. Next day the temperature was 99.6°, and on the morning after it had risen to 101.2.° At this time the hypochondriacal tumor had greatly disappeared, and the man expressed himself as feeling quite well. On examining the right side of the chest, however, Dr. Fagge was a little startled at finding absolute dulness behind, up to the fourth or fifth dorsal vertebra; and over this extent of thorax there was less vocal vibration, marked tubular respiration, and ægophonic character of the voice, which afforded conclusive evidence of a large effusion of fluid. There was very slight pain about the points where the punctures had been made, but no pleuritic pain. The man lay on his back, and was quite comfortable. The liquid had evidently been squeezed through the puncture in the diaphragm into the pleural cavity. The man went on perfectly well, and the chest symptoms disappeared entirely. Twenty days after, all traces of the abdominal tumor had disappeared."

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* Althaus, op. cit., p. 645. See also Med. Times & Gaz., Nov. 19, 1870.

GOITRE (BRONCHOCELE).

Althaus and Mackenzie have experimented with the electrolytic treatment of goitre with a measure of success.

Althaus says, as the result of his experience, "I believe that all cases of bronchocele, however large, may be cured by electrolysis if the treatment is persevered in for a sufficient time. The cystic variety is, of course, much more rapidly curable with it than the solid."*

Mackenzie says:—"I consider that electrolysis is very useful in cases of moderate duration—six months to two years—when of yielding consistence;" and he reports one case where the result was complete:—

> The disease had been coming on two years. Both lobes were affected, each of which appeared about as large as a moderate-sized orange. The neck measured eighteen inches round. After a few séances of electrolysis, the tumor in the course of a month was so reduced that the neck measured but fifteen inches. Internal medicine and the external application of tincture of iodine had been previously tried without effect.

DISEASES WHICH ARE TREATED BY GALVANO CAUTERY.†

REMOVAL OF TUMORS.

A case which did much to popularize galvano-cautery was one of successful removal of cancer of the larynx, by Middeldorpf:—

> The tumor was situated "in the upper laryngeal region, above the superior thyro-arytenoid cartilage." Doubtful prognosis was given, since the ordinary operative procedures were deemed unadvisable. After three unsuccessful trials the tumor was seized by the loop and the battery closed. A few turns of the wheel completely separated the tumor, and it was removed by the finger. Neither the epiglottis nor the larynx was injured.

POLYPI.

Polypi in various situations are now quite frequently removed by the galvano-cautery, by those who are so fortunate as to have the necessary apparatus.

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* Op. cit., p. 643, et seq.

† The leading indications for the use of galvano-cautery are given on p. 622.

Brenner[*] reports the successful removal of a *naso-pharyngeal polypus* by the galvano-cautery.

The same author states, galvano-cautery can be efficiently used in the treatment of *lupus*, and reports in detail a case in which the patient, after the operation, had remained entirely free from the disease.[†] Brenner also gives full details of a successful case of *amputation of a diseased tongue* in a patient 62 years of age, by the galvano-cautery.[‡]

Recently Adams[§] has in the same way removed an *epithelioma* on the side of the tongue without loss of blood.

Dr. Robert Lee[‖] reports a case of scirrhous tumor of the right breast that had reappeared after two operations. It was removed by galvano-cautery, and after six months there had been no return.

Dr. J. Solis Cohen, of Philadelphia, informs us that he is in the habit of using the galvano-cautery for the removal of nasal, pharyngeal, and laryngeal tumors, and with excellent success.[¶] Prof. Türck, of Vienna, has used the galvano-cautery for the removal of tracheal tumors. Dr. Jacoby,[**] of Breslau, reports four cases of auricular neoplasms treated by galvano-cautery.

AMPUTATION OF THE NECK OF THE UTERUS.

Drs. J. Kammerer and Guleke[††] report the following successful amputations of the neck of the uterus by the galvano-cautery :—

"Catherine D——, aged 43, German, fourteen years married; has had five children, the last one two years previous to operation; prolapsus had existed

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[*] Op. cit. Bd. 11, p. 297.

[†] Loc. cit., p. 299.

[‡] Loc. cit., p. 285.

[§] *Lancet*, Oct. 29, 1870, p. 602.

[‖] *Lancet*, April 2, 1870.

[¶] Those who desire to specially study the application of the galvano-cautery to diseases of the larynx, are referred to the monograph of Dr. Rudolph Voltolini, entitled, Die Anwendung der Galvano-Kaustik im Innern des Kehlkopfes und Schlundkopfes. Wien, 1867.

[**] Archiv für Ohrenheilkunde, V., p. 1, et seq.

[††] Thomas on Diseases of Women, p. 518, 1869.

since her fourth delivery; the vagina was wholly everted; there was considerable cystocele and rectocele; uterine cavity measured over five inches; operated on the 8th of April; on the 16th was allowed to walk about; left the dispensary on the 25th; examination May 18th; uterine cavity measured three inches; uterus in normal position; cystocele entirely gone; anterior wall of vagina tense; posterior wall somewhat relaxed; slight rectocele still existing."

"Amelia S——, aged 40, German, fifteen years married. Has had four children; the last one two years previous to operation. There was eversion of the vagina, cystocele and rectocele; uterine cavity measured five inches; operated on the 17th May; four weeks after the operation the uterus was retroflexed; there was no prolapsus or rectocele, but a slight cystocele still remained."

DISEASES WHICH ARE TREATED BY A VARIETY OF METHODS OF USING ELECTRICITY.

Discussion of Tumors.—Tumors may be discussed by all forms of electricity in all the methods of application:—

Galvanic chains or belts.
Faradization.
Galvanization.
Electrolyzation.

Of these methods the last is decidedly the most effective, and yet very decided results in the discussion of tumors have been obtained by simple external faradization. The faradic current, on account of its greater mechanical effects, appears, on the whole, to be more efficient for external use than the galvanic.

By faradization.—Boulu cured two and improved four tumors by the application of magneto-electricity. He applied metallic plates to the tumor, and connected them with moistened conductors.

Duchenne claims to have dispelled two lymphatic tumors of the neck by external faradization.

We have treated a few non-malignant tumors of various kinds by faradization. The results are sometimes decided, sometimes negative. Usually some reduction can be caused, and, in some cases, the effects begin to appear after a single application.

Lipoma or fatty tumors are exceedingly indisposed to yield to faradization. Electrolysis would be more effective for these cases.

Meyer* reports the cure of a glandular swelling on the side of the neck by the use of the galvanic and faradic currents. The tumor was of the size of a hen's egg, and had been growing for two years. Eight applications of the galvanic current, directed transversely through the tumor, did little good. The effect of a ten minutes' application of the faradic current was immediate, and after 60 applications the tumor was reduced to the size of a peach-stone.

The same writer reports a remarkable result in the case of a tumor of the size of a child's head, and of great hardness, situated between the head and the scapula. An operation was deemed unadvisable, and the faradic current was passed through the tumor by means of brass plates covered with sponge for an hour to an hour and a half at a time. After 56 applications the tumor was reduced one-half, and had become softer. After 273 applications the tumor was so far reduced that the patient could turn his head to the right with ease, which before had been impossible.

The chief value of the above cases is to show the possibility of reducing tumors by external faradization; it is not probable that the method will ever supersede electrolyzation, although for those cases where it is successful it presents the obvious advantages that it is not painful, and that it leaves no unpleasant after-effects, and therefore does not, like electrolyzation, compel the patient to change in any manner his mode of life even for a single day. Those who experiment with this method would do well to try *protracted applications for several hours daily, and repeated several times a week.*

Althaus reports the following cases:—

"*Case of nævus of the eyelid—Operation—Cure.*

"In July, 1866, Mr. White Cooper requested me to see with him a lady aged 28, who had a congenital nævus of the right lower eyelid, of the size of a small pea, which it was thought desirable to remove. I expressed the opinion that this might be safely done by the electrolytic treatment, without hemorrhage, and without subsequent inflammation, suppuration, or sloughing; we therefore met on the 23d of July, in order to perform the operation. As the patient was of a highly sensitive constitution, chloroform was administered by Dr. Allan, of Hyde Park Terrace, the ordinary medical attendant of the lady. As soon as she was fairly under the influence of it, Mr. White Cooper introduced a needle connected with the negative pole of ten cells of the battery into the right half of the tumor, and I closed the circuit by placing a moistened electrode connected with the positive pole to the skin of the neck. The current was then allowed to pass for two minutes, after which the needle was withdrawn. Not a drop of blood was lost, either on introducing or on withdrawing the needle. The patient recovered well from the chloroform, and said that she felt no pain in the part that had been operated upon, but merely a slight stiffness. The right half of the tumor appeared shrunk and shrivelled up, while the less half had not been altered in any way. This was an interesting circumstance, as it showed that even in so small a tumor as the one described, the action of the current could be exactly limited to that portion of it which was in contact with the needle. We met again on July 26, when the same operation was performed on the other half of the tumor; but this time the patient objected to the use of chloroform, and bore the trifling pain of the galvanism extremely well without it."

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* Op. cit., p. 481.

The nævus subsequently disappeared. It should be remarked that an oculist of reputation had previously declined to interfere with the tumor.

"*Case of capillary growth in the-arm-pit—Operation—Cure.*

"A lady, aged 27, consulted me on November 21st, 1866, on account of a small papillary and highly vascular growth which had first appeared in the right axilla since the commencement of 1865, and had somewhat rapidly increased in size during the last few months. It was one-third of an inch long, and one-fourth of an inch wide in its widest part. I introduced a needle connected with fifteen cells of the battery into the base of the tumor, and allowed the current the same way we have experimented, though not with as positive success, on *corns* and *bunions*.

John Duncan[*] records six cases of nævus successfully treated by galvano-puncture.

FIBROUS TUMORS.

The electrical treatment of fibrous tumors is worthy of investigation. The fact that, in fibrous tumors of the uterus, absorption may be accomplished by systematic pressure and the use of mineral waters,[†] renders it probable that they might also yield to faradization or electrolyzation. A case of this character we have already under observation. Under prolonged faradization the pains have been markedly relieved, and the tumor is apparently softer.

ERECTILE TUMORS.

Only two cases of treatment of erectile tumors by electrolysis have been reported.

A large vascular tumor was destroyed by galvano-puncture at Hospital of Gesu-Maria, Italy. The particulars of this operation we have not obtained.

Drs. L. F. Sass and R. P. Lincoln, of this city, have communicated to us the details of an interesting case of successful treatment of a venous erectile tumor of the neck :—

The patient, Genl. K., aged 33, of nervous temperament, represented that in April, 1869, after a special effort in public speaking, he felt a pain in his neck, on the left side. Six weeks later a small tumor appeared in the locality of the pain, which in a few months increased much in size. It was subsequently reduced by sulphur baths, cathartics, tincture of iodine, etc., but returned, and in February, 1870, was again reduced by the same treatment, which left him, however, exceedingly weak. July 4, during the excitement of a public reception, the tumor again appeared, with severe pain, loss of voice, and feeling of suffocation, so that death appeared imminent; and again it was dispelled by the same treatment. On account of the frequency of these, and the exhaustion that followed the treatment, the patient was compelled to resign the public position which he held, and return home.

When he came under the observation of Drs. Sass and Lincoln, a tumor of the size of a large goose's egg was found on the left side of the neck, in the antero-inferior portion of the region defined by the sterno-cleido-mastoid and trapezius muscles and the clavicle. The trachea was parted half an inch to the right of the median line. The tumor was rounded, smooth, and readily compressible; but after compression it returned to its natural shape.

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[*] *Edinburgh Med. Jour.*, March, 1870.

[†] Thomas on Diseases of Women, p. 421.

An attack of indigestion, active exercise, or mental excitement of any kind, would cause the tumor to increase sometimes to twice its usual size.

Sept. 30, 1870, in the presence of Drs. Hammond and Hackley, the patient was anæsthetized and submitted to electrolytic treatment. Four gilded steel needles, insulated to one-half or three-fourths of an inch from their points, were introduced into the four quarters of the tumor; the two upper being one and one-fourth inch apart, and one inch above the lower, which were one inch apart. The two inner needles were connected with the subdivided anode, and the two outer with the subdivided cathode. At first ten, then fifteen elements of a battery similar to Stöhrer's were employed. The strength of the current was increased gradually.

At the expiration of fifteen minutes the two lower needles were disengaged from the current, thus concentrating the whole force upon the two upper; at the expiration of fifteen minutes more the needles were removed.

During the operation all the prominence of the tumor disappeared, and a delicate examination detected a hard mass in its place; not a drop of blood escaped on the removal of the needles. The skin over the tumor presented a bright blush, and the trachea had returned to its proper position. The patient kept quiet for three days, using a cold-water compress. At the end of that time the soreness, which had been considerable, had nearly all passed away.

At the latest date, October 24th, the patient was well, and "the induration in the neck was steadily diminishing in size."

The important feature in the above case was the *immediateness and rapidity of the result.* In a séance of half an hour the tumor disappeared, leaving only an indurated mass.

Judging from the history of the case, it is probable that the same result might have been obtained by external faradization a number of times repeated.

MALIGNANT TUMORS.

Scirrhus and encephaloid cancer may be treated electrically.

Cancer of the breast in a lady of middle life—General debility—No special treatment of the tumor—Relief of pain and improvement of the general health under general and localized faradization.

CASE 158.—Mrs. D——, a lady of middle life, consulted us, in the fall of 1867, for a tumor of the right breast, of the size of a small orange, which was evidently of a malignant character, and which, for a number of months, had caused her much pain and uneasiness. The patient was gradually becoming feeble, was much alarmed, and before consulting us had not the courage to obtain any opinion of the nature of the tumor. The patient was referred to Prof. W. H. Van Buren, who decided that the tumor was malignant, and thought that an operation was hardly advisable. For the purpose of relieving her pain, and improving the tone of the system, the patient received a short course of treatment by general faradization, and with decided though not remarkable results. The pain was somewhat relieved, and there was improvement in appetite, sleep, and muscular strength. No special attention was given to the tumor. Of the issue of the case we have not been informed.

Supposed Cancer of the right breast, of six months' standing—Size of an egg—Intense pain—Tumor dissipated by five faradizations.

CASE 159.—Mrs. A——, of Chicago, fell under our observation September 4, 1866. Since the 1st of March there had been a tumor on the right breast, that had gradually increased in size. The tumor was of the size of a hen's egg, and was hard to the touch. At times she had suffered from intense lancinating pain. A number of medical men in the West had seen the tumor, had pronounced it to be a cancer, and had advised its removal by the knife. The distress of the patient after she learned the true nature of her disease was very great.

As an experiment purely, and in the hope only of being able to relieve temporarily the pain, we tried faradization of the tumor. After the second application there was a manifest diminution in size, and the pain was notably diminished. After the fifth application, September 14, both the tumor and the pain had entirely disappeared. The patient left the city overjoyed with the result. Since that time we have heard nothing from her.

Althaus,* who has studied this subject for several years, states that the electrolytic treatment is useful in scirrhus and encephaloid cancer, but that the former variety requires a powerful current and considerable time to accomplish a reduction. He states furthermore that "the peculiar lancinating pains of cancer generally seem to disappear, or at least to diminish considerably, soon after the commencement of the electrolytic treatment, and long before the whole tumor is destroyed." Gherini has accomplished about the same as Althaus.

Dr. W. Neftel† reports a case of malignant tumor of the mammary region of the left side that was treated by electrolysis. Twice the tumor had been extirpated by Dr. Sims, but had reappeared, and when the electrolytic treatment was proposed it was of the size of an orange. The tumor which was taken out in the second operation had been examined by the microscope, and found to be carcinoma.

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* On Tumors and other Surgical Diseases. 1867. pp. 22, 23.

† *Medical Record*, Sept. 1, 1869.

April 27th, and May 4th and 7th, the operation of electrolysis was performed with the *serres fines* conductor of Althaus, connected with Siemen's-Halske's elements. The first operation was made with 10 elements, and lasted two minutes; the second with 20 elements, and lasted five minutes; the third with 30 elements, and lasted ten minutes.

After the operation the tumor was softer, but increased in size. No febrile symptoms apppeared. In one month the tumor was smaller and softer; in two months it had almost, and in ten weeks quite disappeared. The general condition of the patient also improved.

One year and a half after the treatment, Dr. Neftel* reported that the patient continued well, and stated that he had similarly treated eleven other malignant tumors, mostly scirrhous, and with successful results, and that in no case had the tumors returned. Manfredini has entirely removed a cancer of the lower part of the thigh. Von Bruns states that he has never succeeded in removing, or even in greatly reducing, a cancerous tumor by electrolysis, and that absorption does not occur.

Dr. A. Jacobi† states that he has treated cases of scirrhus by electrolysis, and has seen the tumors decrease in size under the treatment. He states furthermore that he has seen suppuration and sloughing result from the treatment.

For the purpose of electrolyzing *malignant tumors of the uterus*, we have devised a bifurcated needle, connected with a handle similar to that of the *intra-uterine electrode.*

Farado-Electrolyzation.—The distinct and obvious advantages that both faradization and electrolyzation present for the treatment of tumors, suggested to us the idea of using them simultaneously. The faradic current may be applied to the tumor externally by means of moist sponges, while the galvanic current may be allowed to operate internally by means of needles connected with the negative pole. In this combined treatment the tumor is submitted to a threefold action—the electrolytic processes of the galvanic current, the mechanical action of the faradic current, and also the local anæsthesia of the faradic current, which somewhat diminishes the pain of the electrolyzation.

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* *Medical Record*, Oct. 1, 1870, p. 355.

† *Medical Record*, Oct. 15, 1870, p. 363.

The following case was treated partly by this method, which, so far as we know, we were the first to use.

Scirrhus of left breast, of three months' standing, treated by electrolyzation and farado-electrolyzation.

CASE 160.—Mr. F., aged —, a patient of the surgical department, Demilt Dispensary, was sent to us by Dr. Stephen Rogers, Nov. 21, 1770, with a tumor of the left breast, which he pronounced to be of an unmistakably malignant character. The tumor was hard and presented distinct nodules. There was retraction of the nipple, some involvement of the axillary glands, and pain of considerable severity.

Nov. 21.—The patient was treated by electrolysis, two needles connected with the negative pole of Stöhrer's battery, gradually increased up to twenty cells, being applied in the hardest point of the tumor, about one inch from the nipple and one half inch from each other, and the positive pole being applied by a moistened sponge electrode on the surface near by. The operation lasted three minutes. Although local anæsthesia by ether spray was used before and during the operation, considerable pain was experienced. At the conclusion of the electrolytic treatment the tumor was faradized for ten minutes by a current gradually increased up to a point when it could be comfortably borne. At the conclusion of both treatments, the tumor was apparently softer than before.

Nov. 28.—The patient was thoroughly etherized and treated simultaneously by electrolyzation and faradization—*farado-electrolyzation*. The operation lasted twelve minutes, thirty cells of Stöhrer's battery being used and a strong faradic current. Three needles were inserted. The needles, which, on account of the hardness of the tumor, were at first introduced with some difficulty, soon became so loosened by the electrolytic action that they slipped out unless care was taken to keep them in.

At the places where the needles (which were not insulated) were inserted, superficial inflammation appeared, and from the nodules around the nipple some sloughing took place during the week following the operation. Poultices were applied and the patient kept quiet. The treatment was resumed after ten days, only faradization being employed Dec. 20. The tumor is softer, and apparently smaller, and the pains have decidedly diminished.

The facts variously accumulated and now accumulating on this subject seem to justify these conclusions :—

1. Malignant tumors, scirrhous and encephaloid, at least in certain stages and in a proportion of cases, may be discussed both by external faradization and electrolyzation with strong galvanic currents, probably also by external galvanization. Of these methods faradization is the more convenient, and is but little if at all painful, but in many cases of scirrhus it would probably

fail. Electrolyzation is the more rapid and effective, but it requires local or general anæsthesia, and may cause suppuration. The two methods may be used simultaneously.

2. Both of these methods may have a decided effect in relieving the pain, even when they do not succeed in entirely destroying the tumor.

3. Patients afflicted with malignant tumors, as with many other serious diseases, would probably be susceptible of improvement in their general condition under general faradization, even when no attention is given to the local disorder.

4. The great and important question, whether the tumors return as speedily as after removal with the knife, or whether they return at all, or what proportion of cases will be successful, and in how advanced stages the treatment may be used without causing inflammation and suppuration, and to what extent the occurrence of suppuration will interfere with the treatment, can only be answered by a large number of cases carefully treated by various methods, and closely watched for several years.

ULCERS.

The earliest attempts to treat ulcers by electricity were made by Crussel, in 1847.

The same treatment has been used in syphilitic ulcers by Kyber of Cronstadt, Rosenberger of St. Petersburg, and in the majority of their reported cases with success.

Spencer Wells has also used galvanism with success in the treatment of ulcers. He employed zinc and copper or silver plates connected with a wire.

Ulcers may be treated with both currents by means of metallic disks or plates covered with soft sponge. *Galvanization* serves to cure in such cases partly by its *electrolytic* effects. One electrode may be applied to the ulcer, and the other to the *nearest large nerve-branch or plexus, or to the sympathetic or spinal cord.* The applications should not be excessively painful. In some cases decided results may follow a single application of electricity to an ulcerated surface. In the case of an ulcer of the leg of a girl 8 years of age, one faradization with a current of moderate strength so improved the nutrition of the parts that healing at once commenced, and in a short time entire recovery took place without any further treatment. Ulcers may also be cauterized by the galvano-cautery. Ruschenberger has successfully *faradized bed sores.*

In the treatment of ulcers, and indeed of many conditions, it is a convenience to have one electrode kept in a fixed position without the aid of the physician or of an assistant. For this purpose we have devised a series of adjustable electrodes, provided with a rubber belt which can be passed around the limbs or body, one of which is represented in the cut. They may be of various sizes, and, like other electrodes, may be covered with sponge, linen, flannel, or chamois. The smaller sizes are for the arms and legs, and back of neck; the larger for the back and coccyx, and may be used in general electrization instead of the sheet of copper at the feet. (See p. 192.)

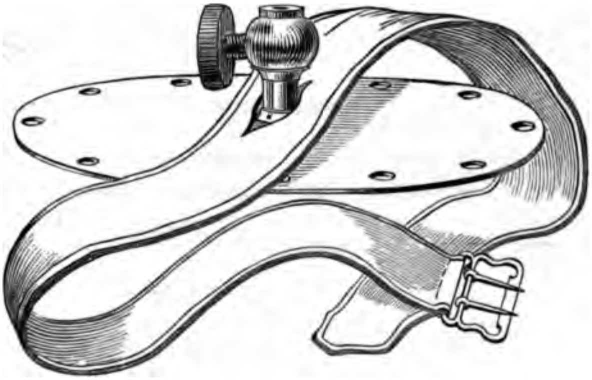

FIG. 93.—Adjustable Electrode.

FISTULÆ AND SINUSES.

Nunn[*] reports successes with the galvanic current in ulcers, and in the treatment of sinuses he had obtained good results with a current from Pulvermacher's chain.

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[*] *Lancet*, July 28, 1866.

Fistulous ulcers of the hip and thigh, existing two years—Localized faradization causes the ulcers to heal from the bottom—Recovery in three months.

CASE 161.—J. V., a German, aged 35, stated that in March, 1864, he fell upon his hip, and received a severe contusion that caused much pain, and resulted in a complete loss of the power of locomotion for over a year. In October, 1866, he fell under our observation. He was then suffering from three fistulous ulcers on the thigh and hip, through either of which a probe could be passed to the bone. These sinuses, which had existed for two years, had on several occasions apparently disappeared, but in a few weeks the discharge invariably reappeared, rendering it evident that the cavity had not healed from the bottom. Applications of the faradic current were administered some three times a week to the surrounding parts and to the whole length of the sinuses. No especial result was observable during the first six weeks, but soon after the ulcers evidently began to heal from the bottom, and at the close of the third month of treatment the cure was complete. So late as October, 1869, the patient had suffered no relapse.

Stumps after amputation that are slow to heal have been successfully treated by electricity, like ordinary ulcers, by Dr. Geo. K. Smith and by Dr. Snively, of Brooklyn.

HÆMATOCELE.

Hæmatocele of the pelvis or pudenda, or of other portions of the body, may be treated electrolytically or by faradization.

GANGRENE.

Gangrene may be treated electrically in various ways, but especially by electrolysis and galvano-cautery.

CARBUNCLES AND FURUNCLES.

Carbuncles and furuncles might be treated by electrolyzation. Dr. Sass informs us that a number of years since he used this treatment in two instances with good effect.

BURNS.

Burns in a subacute stage might not unlikely be helped toward recovery by faradization or galvanization.

FROST-BITE (CHILBLAINS).

We are not aware that any attempts have been made to treat chilblains by electricity. It certainly would not be irrational to try the power of galvanization in this disease.

SEROUS EFFUSIONS.

SYNOVITIS.

In *effusions* of an acute and very sensitive character electricity is usually not indicated, but in the subacute and chronic forms it is of great efficacy. The treatment should be directed by the cause and stage of the disease, and by the results of trial in each case.

The treatment of those cases that depend on rheumatism, or hysteria, should be constitutional as well as local. In some cases general faradization, with special attention to the affected joint, is sufficient; in others the general treatment is sensibly aided by galvanization or faradization of the joint.

Whether the galvanic or faradic current is to be preferred for local applications can only be determined by the results of trial. Our custom is to begin with the faradic current, and to use it so long as benefit results, and then to change to the galvanic. It should be borne in mind that the greater chemical effects of the galvanic current are in these cases frequently more than counterbalanced by the powerful mechanical action of the faradic. Stable increasing currents are to be preferred.

This is one of the conditions in which localized galvano-faradization may be tried. But whichever current is used, the application should usually be short—from one to five minutes. The electrical treatment of effusions of the joints is much aided by using the hand as an electrode, with gentle but firm manipulation. There is no question that under the influence of "rubbing" have been wrought many important cures in these affections.

Electrolyzation has been successfully employed in effusions. It may be resorted to in all obstinate cases.

Synovitis may be relieved or cured by faradization or galvanization.

Synovitis of the knee, complicated with hemiplegia—Recovery under faradization.

CASE 162.—Mr. Geo. L., aged 35, stated that about the 1st of July, 1866, he was sunstruck; and between the 20th of the same month and the 15th of August, he suffered from three strokes of hemiplegia, resulting finally in total blindness. His sight gradually returned, but by degrees his shoulders became lame and stiff, so that he could with difficulty use them. This state of things continued until about the middle of September, when both knees and ankles commenced to enlarge. In November, when the patient applied to us for treatment, we found him suffering from severe subacute synovitis. Both knees were enormously swollen, the fluid having accumulated to such an extent that the patellæ projected forward more than an inch. Four applications of the faradic current were given, one every day, but with no marked effect, except that the lameness of the shoulders and ankles was much relieved.

He then left the city and was absent one week. On his return the improvement was found to be very great. The accumulation of fluid in the knees had almost entirely disappeared, and the swelling was reduced in proportion. At first, the very strongest current from Kidder's apparatus made no impression, when applied down the spine. The legs were but little sensitive to the electric stream, and the feet and toes, which are generally very readily affected, were remarkably torpid. The applications were continued on Dec. 3d, 4th, 5th, 7th, and 9th, effectually removing this want of sensation, and completely dissipating the remaining swelling and tenderness of the knees.

in the treatment of effusions in the pleural cavity, and for ascites.

Protracted faradization would probably cause slow absoption in such cases.

Prof. Wm. H. Thompson informs us that he has successfully treated a number of cases of pleuritic effusions by faradization.

ORCHITIS.

The electric treatment of orchitis has been particularly studied by Drs. Jules Chéron and Moreau-Wolf.*

They give the results of the treatment in nine successful cases. Their method of treatment was to direct a galvanic current from ten to twenty-four cells of Remak, through the tumor, from two to eight minutes. Sometimes the positive pole was placed on the most painful point of the swelling, and the negative on the spermatic cord. The authors regard the ascending current (up the cord) more effective than the descending.

Most of their cases were cured by a few (from four to ten) applications.

The great advantage which the authors claim for this method of treatment in orchitis is, that the patient is *not obliged to suspend his daily duties, since absolute repose is not necessary.*

The following cases are condensed from the work of Chéron and Moreau-Wolf:—

On the 28th of January, 1869, Dubois, aged 29, mason, came to our dispensary to consult for a blennorrhagia which had been followed by a very painful attack of epididymitis. There was abundant effusion and considerable swelling of the cord. The first application caused a manifest diminution of the *pain* and the *swelling* of the testicles, of the epididymis, and of the cord.

January 29th. A second application caused diminution of the *effusion* and also of the other symptoms. The patient returned 30th, 31st, and on the 1st, 2d, 3d, and 4th of February, at which time the swelling was almost entirely reduced, and the pain and effusion no longer existed.

Seguin, a turner, aged 22 years, had suffered from a blennorrhagia of medium intensity, which had been followed by an orchitis for 24 hours. Seven applications accomplished a cure, from which there was no relapse.

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* Du Traitement de l'Orchite, par l'application des courants continus constants, Paris, 1869.

On the 10th of January, 1869, a porter, 25 years old, presented himself at the dispensary with acute blennorrhagia of medium intensity, for which ordinary treatment by opium, copaiva, etc., was used. Jan. 18, acute orchitis appeared, with the usual symptoms, inflammation of the sheath, effusion and swelling. The testicle was as large as a fist, hard, shining, red, and excessively painful to touch. The cord shared in the inflammation. The pain was so great that the patient could not walk. The ascending current of twenty-five elements was applied, the positive pole on a level with the epididymis, the negative on the cord above the inguinal ring.

After an application of ten minutes, the pain had almost completely disappeared, the tumor was less hard, and almost insensible to touch and light pressure.

The patient *continued his laborious occupation*, and received seven applications. The last application was on the 25th of the month. The testicle at that time was in its normal condition. No auxiliary treatment was used except four lukewarm baths.

Chronic orchitis of six months' standing in a syphilitic patient—Approximate recovery under external galvanization and faradization.

CASE 163.—Mr. W., aged 28, consulted us Oct. —, 1870, for an enlargement of the left testicle that had troubled him for six months. It was about twice the size of the right testicle. There was no pain, but a constant sense of weight. The patient was suffering from secondary syphilis, and had, in times past, repeatedly experienced attacks of gonorrhœa. Stable galvanization with a current that was comfortably borne was employed for ten minutes, the positive pole being applied over the testicle at different points, and the negative pole over the spermatic cord. The patient stated that the testicle felt less disagreeable. In two days there was an apparent diminution in size. Three more similar applications and one faradization produced an almost complete recovery.

ENLARGEMENT OF THE PROSTATE.

The electrical treatment of hypertrophy of the prostate has been studied by Tripier,* who has demonstrated that the effect of faradization of this organ when enlarged is to cause resolution. The rationale of the treatment is substantially the same as for analogous conditions of the uterus. The subject is one that deserves investigation. Either the galvanic or the faradic current may be employed. One pole may be applied internally by means of an insulated catheter electrode or sound, and the other in the rectum against the prostate, by means of a rectal electrode.

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* Manuel d'Électrothérapie, p. 567.

Tripier records a case of a patient, 44 years of age, who suffered from retention of urine, caused by enlargement of the prostate, that had resulted from an attack of gonorrhœa and the cauterization that had been used for it. Hypertrophy of the right lobe was established by examination with the sound, and of the left toward the summit. The size of the gland in various directions was accurately measured. Tripier was called 36 hours after the retention appeared. From Sept. 9 to December 3, thirty applications to the prostate were given with the faradic current for ten minutes at a time. This was found to be too long, and the applications were reduced to three to five minutes. Between Dec. 3 and March 12, forty sittings were given. The size of the gland in various directions was much reduced. The cure was complete and was permanent.

SPRAINS (STRAINS).

Sprains of joints of all kinds may be treated by electrization; faradization and galvanization of the affected part with a mild, stable, or gently labile current are indicated. We have in this way treated all stages of sprains—acute, subacute, and chronic—and almost uniformly, thus far, with beneficial or curative results.

We have not been able to decide which current is preferable.

Sprains in the acute stage or just passing into the subacute stage should be treated by very mild currents and by short applications.

In such cases no electrode is so agreeable as the hand of the operator gently passed over the painful part.

We have treated a number of cases of sprains of the wrist in patients who are engaged in manual employments. In such conditions the localized application of the faradic current alone rapidly brings on the recovery.

Strains of muscles with rupture of fibres, so far as our limited observation goes, do not yield to electrical treatment. In the few cases where we have perseveringly used faradization and galvanization we have not been able to see that the slow improvement was in any degree hastened.

Lameness and swelling caused by a sprain—Relieved by local faradization.

CASE 164.—The power of the faradic current to allay irritation and relieve lameness, in cases of sprains or injuries, was well illustrated in the case of a Mrs. B., directed to us by Dr. Kissam. Her foot was heavily pressed upon by the rocker of a chair, and caused such ecchymosis, pain, swelling, and lameness, that for two months she was unable to walk more than from her house to her carriage. The faradic current, applied over and around the foot a number of times, relieved most decidedly the swelling and lameness, and enabled the patient, in a few weeks, to exercise in walking without serious difficulty.

SPONDYLITIS (POTT'S DISEASE).

Spondylitis is a term that is applied to inflammations of the vertebræ. Among its symptoms are at first changes in shape of the spinal column, obstinate gastralgia, or neuralgic pains in the breast and various parts of the body, and subsequently projection of the diseased vertebræ, deformity of the spine, peculiar attitude and paralysis,* sensitiveness of certain vertebræ, and spontaneous pains in the spine.†

The form in which it appears is in the lower cervical and upper dorsal vertebra, with the symptoms of neuralgia in the arm, or neck, or lower limbs. Some cases of torticollis, and even of chorea, may depend on disease of the vertebra. Other symptoms are paralysis, atrophy, or contraction of certain muscles. In

SPINAL CURVATURE.

Lateral curvature of the spine, depending on relaxation of the muscles and ligaments, and associated with general debility, is a condition for which general and localized faradization and galvanization of the sympathetic are well indicated, and in which they have wrought most important results. General faradization alone is pretty sure to be of service, both in raising the tone of the system and in permanently relieving the curvature. The electrical treatment may be used in connection with mechanical appliances.

PSEUDO-ARTHROSIS.

Burman obtained a good result from electrical treatment of a transverse portion of the tibia and fibula. After the lapse of a month the bones had not united. A bandage was applied and a current (whether faradic or galvanic is not stated) was applied for half an hour by two needles. Suppuration followed, callus was formed, and entire recovery took place.

Hall also obtained a successful result in a fracture of the thigh by the same treatment. The operation was repeated daily for two weeks.

Hahn also reports a successful result from electro-puncture in a case of fracture of the thigh. He used at first magneto-electricity, and subsequently the galvanic current. No improvement followed the use of magneto-electricity, while the galvanic current brought on inflammation in six days. The inflammation thus excited produced a union of the fracture in ten days.

It is altogether probable that successful results might be obtained in pseudo-arthrosis by external galvanization or faradization with strong currents.

HERNIA.

Delaux reports a case of incarcerated femoral hernia in a woman who refused to submit to an operation. The tumor disappeared after a few applications. The first application was directed to the hernia, and in the other applications one pole was applied to the hernia and the other in the rectum. Before electrical treatment was tried the patient was growing worse. Faradization might give tone to the weakened muscles in reducible hernia, and for this purpose we have employed it in a single instance; of the results we have not been informed.

GONORRHŒA.

It would not be unreasonable to suppose that gonorrhœa in its subacute stage might be treated by electrization with at least as satisfactory results as subacute inflammations of the mucous membrane.

We have had opportunity to test faradization in two cases of gonorrhœa while the inflammation was in quite acute stages.

Gonorrhœa—Temporary increase of secretion under faradization—Recovery.

CASE 165.—A gentleman requested us to try on him electrical treatment for an attack of gonorrhœa that he had recently contracted. We consented to do so with the understanding that the treatment should be considered as experimental, inasmuch as we had treated but one case of gonorrhœa by electricity.

We employed local external faradization through the penis, without regard to the direction of the current. After four applications he represented that he was cured. In this, as in the other case, there was some temporary increase of the urethral secretion after the first two applications

MORBUS COXARIUS (DISEASE OF THE HIP-JOINT).

This condition might be treated electrically, with a twofold object of hastening the recovery of the local lesion and improving the general condition. The methods of treatment that would seem to offer most hope are stable faradization or galvanization of the diseased joints, five, ten, or fifteen minutes daily, alternating with general faradization. This treatment might be used in connection with the ordinary method by extension.

TOOTHACHE (ODONTALGIA).

The pathological conditions that give rise to toothache are so various, and the anatomical difficulties in the way of direct localization of the current in the affected nerve are so great, that uniform results from electrical treatment cannot be expected.

The familiar cause of toothache is exposure to cold. Although the nerves connected with decayed teeth are more liable to be affected after such exposure, yet the nerves of any or of all the teeth, even when they are perfectly sound, may also become hyperæsthetic and cause exceeding distress, either from exposure to cold, or from anæmia or nervous exhaustion.

Among the specific pathological conditions that give rise to toothache are, *odonitis*, *periodonitis*, *alveolar abscess*, simple irritation produced by the *presence of the diseased tooth*, *rheumatism*, *reflex action*, and probably also *anæmia*, *neurasthenia*, and *various blood poisons*.

Those toothaches which arise from *rheumatism*,* *anæmia*, *neurasthenia*, and *blood poisons* may be treated electrically on the same principle as similar symptoms in other parts of the body.

The applications may be *external* or *internal*, either with the faradic or galvanic currents. Externally a moistened sponge electrode connected with the positive pole may be applied for a few minutes over the seat of the pain, while the other is held in the hand of the patient. The *electric moxa* might also be tried.

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* Frommhold gives an interesting chapter on *Odontalgia Rheumatica.* See his Electrotherapie mit besonderer Rücksicht auf Nerven-Krankheiten, 1865, p. 404.

The application may be made internally by means of a small insulated electrode, with a metallic extremity. (The nasal or laryngeal electrode will serve the purpose.)

In both the external and internal applications it is well to begin with a mild current, and gradually increase it up to the point where the patient can conveniently bear it.

HEMORRHOIDS (PILES).

Hemorrhoids in all their stages have been submitted to electrical treatment. In the milder stages they may be treated like *prolapsus ani*, with the rectal electrode (see p. 484). A very strong current will usually be borne in the rectum without discomfort. Hemorrhoids may also be treated by electrolysis, or they may be removed by the galvano-cautery.

CLUB-FOOT (TALIPES).

In club-foot it is not unfrequently an advantage to combine faradization or galvanization of the partially paralyzed muscles with the use of mechanical appliances.

man calculus in water, submitted it to the action of a voltaic pile of 120 elements for twelve hours. Platinum wires were placed against the calculus, on opposite sides. Fine powder soon appeared. At the end of the operation the calculus was found to have lost 12 grains in weight, the original weight having been 92 grains. It was again submitted to the current for 16 hours, at the end of which time it was reduced to very small fragments that could have easily passed the urethra.

Their second experiment was made on a fusible calculus in the bladder of a living bitch, into which warm water had been injected. The application, which lasted an hour, was repeated 12 times during six days. The calculus had become so friable that the operation was not repeated. Examination of the bitch after death showed evidence that the bladder had been injured by the operation.

In 1835, Bonnet proved that by applying platinum electrodes to the opposite sides of a calculus in a solution of nitrate of potash, electro-chemical decomposition ensued, by which nitric acid appeared at one electrode and potash at the other. The effect of these two substances was to dissolve the calculus. Stones composed of phosphate will be dissolved on the acid, and those composed of uric acid or urate of ammonia on the alkaline side. Under this action the stone, unless very hard, becomes friable and falls to pieces. These experiments were confirmed by Bence Jones, who also found that calculi of oxalate lime could be slowly dissolved in the same way. Neither of these experimenters attempted the dissolution of calculi in the human bladder.

ELECTRIC EXPLORER OR PROBE.

This apparatus (Fig. 94) indicates at once the presence of metallic bodies in gunshot wounds.

Fig. 1 represents its natural size. Fig. 2 shows one of the exploring sounds. There are generally two sounds, one stiff, the other flexible.

The trembler or needle is so arranged as to resist all shocks and fulfil the following conditions :—

1. It is very portable, and in all possible positions can be carried in the vest pocket, or in the ordinary surgical case.

2. It cannot be deranged.

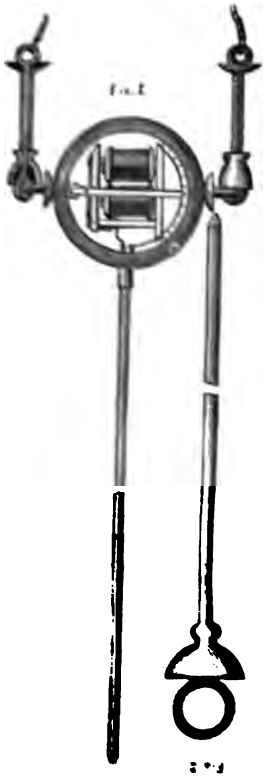

Fig. 94.
[illegible]

3. Three senses take part in making the exploration—the hearing, the touch, and the sight.

4. It indicates with certainty the presence of a ball by the movement of the trembler, an effect which is only produced *when the circuit is closed by a metallic body.* Experience has shown that the contact of organic tissues, even with a battery of 15 elements (and probably with even a greater number), will not put the trembler in vibration.

5. The explorer indicates at the same time the depth at which the ball is situated, and in some cases also the flexible sound preserves the form of the canal through which it passes.

The battery is in a case made of hard rubber. This holds the elements, zinc and carbon, which fill only half. The other half is occupied by the exciting liquid, a solution of sulphate of mercury. When the case is reversed, or in a horizontal position, the liquid flows on to the element and a current arises; when the case is in a vertical position the metals are not touched by the liquid, and there is no current.*

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* The first apparatus for the electric exploration of wounds was devised by M. Favre, of Marseilles, of which the following description was given by Nélaton, in remarks to his class at the *Hôpital des Cliniques*: "Two conducting wires are placed in a sheath, or the two electrodes may be covered by an isolating substance. These wires are in communication with a battery of only one couple, and a galvanometer is fastened on one of the wires. If you introduce the end of these into a wound, the contact of the soft parts, the bones,

EXTRACTION OF FOREIGN BODIES BY THE ELECTRO-MAGNET.

Dr. Delore* has suggested the electro-magnet as a means of extracting foreign bodies from the eye, urethra, auditory canal, etc. He states that the magnet has been used for the purpose of extracting pieces of iron and steel from the eye since the days of Fabrice de Hilden. Delore's attention was called to the subject by an attempt which he made to extract a piece of a pin from the external auditory canal. A slender magnet was prepared by M. Fasse, which could be bent at will, but it was found to be not sufficiently powerful. Then M. Fasse suggested the idea of using the electro-magnet for this purpose. With this view he constructed a small electro-magnet, composed of a stem of iron, with a bulbous extremity, and covered with several windings of insulated copper wire.

The force that is obtained is in proportion to the strength of the current used to magnetize the iron, the number of spirals, and the diameter of the magnet.

In order to ascertain how much power was necessary to extract needles from the body, a number of experiments were made.

"A needle embedded in the horny substance of the hand to the depth of three millimetres requires for its extraction a traction of 89 grammes."

"Embedded sixteen milli. deep in the heel of a cadaver requires 400 grs."

"Embedded four centimetres deep in the calf of the leg it requires 400 grs."

"If it has perforated the cornea it must have a traction of 39 grs."

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or pus, is not sufficient to establish a current, but if the ends come in contact with a metallic body, the needle of the galvanometer will rise, this being a proof that the circuit is complete. Only one couple, however, should be used, so as to avoid the decomposition of the fluids in the wound, which would immediately give rise to a current."—(*Am. Jour. Med. Science*, vol. xlv., 1863, p. 218.) During the recent Franco-Prussian war an "*Electric Bullet-seeker*," that strikes a little bell when metallic connection is made, has been successfully used.

* Translated from *Lyon Médicale*, in *N. Y. Medical Gazette*, Aug. 20, 1870.

The advantage claimed for this method of extracting foreign metallic bodies is that "it produces no sensation on the surface of the tissues," and also is less liable to injure them than forceps or probes.

ELECTRO-CHEMICAL BATHS.—REMOVAL OF POISONOUS METALS FROM THE BODY.

In 1855 Vergnés and Poey, of Havana, reported to the French Academy a method of removing poisonous metals from the body by means of the galvanic current. Vergnés, while practising electro-plating in 1852, had brought on obstinate ulceration on his hands. He placed his hands in an electric bath, connected with the positive pole. In 15 minutes a metallic plate connected with the negative pole in the bath was covered with gold or silver from the ulcer. A few such treatments cured the ulcers.

An electro-chemical bath is taken as follows: An isolated metallic tub is placed on an isolated bench. The tub is filled with water, acidulated with nitric acid of mercury, gold or silver, and sulphuric acid if lead is in the patient. The patient is placed in the bath, and the tub is connected with the negative pole, while the patient takes the positive pole, part of the time in the right and part of the time in the left hand. The current now enters the arms, passes through the body to the tub. The metal that is extracted from the body is found on the sides of the tub, in the water in the tub, and in the atmosphere of the room from evaporation.

These experiments were confirmed by Caplin and Meding. Meding extracted mercury from a patient in this way. Vergnés employs electro-chemical baths also for introducing medical substances into the body. The patient sits in the bath containing the solution, and in the position described, and absorbs the substance while the current is passing. Among the remedies that Vergnés employs for the purpose are phosphate of iron and nitric acid. There is little question that the passage of the current through the body, immersed in certain medicated solutions, aids in the absorption of some portion of the compound. This can be demonstrated by placing a solution of atropine—one grain to an ounce of water—on the stomach and applying the galvanic, or even the faradic current. The pupil will sometimes become dilated.

ELECTRO-ANÆSTHESIA.

The benumbing effects of the faradic electric current on the nerves may be utilized for the production of local anæsthesia. (See *Electro-Physiology*, p. 60.) It is only indicated for slight or at least short operations, such as the opening of abscesses, felons, buboes, the extraction of foreign bodies and of teeth.

For opening abscesses a strong faradic current should be directed through the parts as the incision is made. The relief thus afforded is slight, but is positive, and is not unworthy of a trial.

Electro-anæsthesia has been chiefly used in the extraction of teeth, where it is certainly of some service. The patient places his foot in a metallic slipper, or on a plate, or holds an electrode in the hand, while the circuit is completed as soon as the forceps of the dentist, which is connected with the battery, seizes the tooth. It is well to connect the forceps with the negative pole, because it is the stronger.

The painful contractions produced by the passage are certainly disagreeable, for a current of considerable strength is required, but the pain of the extraction is less severely felt than it would be when made unaccompanied by the current.

This method of producing local anæsthesia was at one time somewhat popular among dentists, but partly on account of the fact that it is at best an imperfect method of preventing the pain of the operation, partly on account of the mechanical difficulties in the way of its employment, and partly, also, on account of the popularization of nitrous oxyde, it has fallen into disuse.

Electro-anæsthesia may be utilized for the relief of the irritation caused by the application of caustics to the larynx, eye, or uterus.

HYDRO-ELECTRIZATION.

We have recently devised a method of applying electricity by means of a continuous stream or jet of water flowing from a metallic tube—or one that has a metallic orifice—connected with one pole, while the body of the patient is in any convenient way con-better than cold, and is therefore preferable, except for those cases where the tonic effects of cold are indicated. The conducting power of the water is also increased by the addition of common salt, and various medicinal substances which are ordinarily used for the treatment of the conditions for which hydro-electrization is indicated, and may therefore be properly combined with it. The results of our various experiments with this method will in time be made public.

ELECTRO-MEDICATION.

Long ago it was contended by Fabrè-Palaprat, Orioli, and Vergnés (see p. 676) that medical substances could be introduced into the body by means of the galvanic current, but by Remak, Rosenthal, Tripier, and others their statements have been discredited. From our experiments (see p. 676) it would seem that atropine might be introduced into the system by means of the faradic current in sufficient quantities to slightly affect the pupil.

Recently Beer, of Vienna, and Von Bruns* have succeeded in introducing iodine into the dead and living subject, by means of the electrolysis of iodide of potassium. For this purpose they have used a glass tube, containing a solution of iodide of potassium (1 to 1, or 1 to 2), tightly corked at one end, and at the other covered with cloth or a piece of bladder, and connected through the cork with the negative pole of the galvanic current by a piece of platinum. The positive electrode may be of a similar construction, or an ordinary sponge electrode.

If by this arrangement an application be made through the face —an electrode being placed on each cheek—for a few minutes, traces of iodine can be detected in the saliva. A good test for iodine is *disulphide of carbon*, which will detect one part in 1,000,000 parts of water, by the purple-red color which it produces. Another test is glycerine, which, mingled with iodine and electrolyzed, gives a dark blue or black line. The electrolytic introduction of iodine has been used in *glandular swellings* (as goitre), *effusions in the joints*, *periostitis*, and with asserted success, after simple galvanization has failed.

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* Die Galvano-Chirurgie oder die Galvanokaustik und Elektrolysis bei chirurgischen Krankheiten. Tübingen, 1870, p. 133, *et seq.*

GLOSSARY.

Explanation of the terms used in ELECTRO-THERAPEUTICS, *including also many of the terms of* ELECTRO-PHYSICS *and* ELECTRO-PHYSIOLOGY.

WITH the progress of the study of Electricity in its relations to Physics, Physiology, Practical Medicine, and Surgery, there has arisen a new and extensive terminology.

The terms used, especially in Electro-Therapeutics and Electro-Physiology, have been introduced by different observers, in various countries, and in different languages, and are all necessarily based on an incomplete knowledge of the mysterious force whose phenomena and manifold relations they aim to describe. It was inevitable that a nomenclature devised under such circumstances should be more or less inaccurate and confused. This inaccuracy and confusion has been still further increased by the carelessness of writers, who have misunderstood and misapplied these terms, and greatly perverted them from their original meaning. It would be difficult to find any two authors who entirely agree in their use of terms, even of those which are most frequent and most important; and readers who are not thoroughly familiar with all branches of the subject in the various languages, and with the incorrect as well as the correct phraseology, will be more or less bewildered.

It is believed, therefore, that a list of the words and phrases employed by writers on Electricity, which should present their original and derived meanings in their various combinations, with their correct and incorrect synonyms, would be of service not only to those who consult this volume, but to all who occupy themselves with the department of Electro-Therapeutics.

The need for such a list is rendered the more imperative from the fact that many of the terms it includes cannot be found in the most recent dictionaries.

The terms which we have introduced, or to which we have given a new combination or attached a peculiar signification, are designated by a star (*). The figures refer to the pages in the present work where the terms to which they refer are explained.

AMALGAMATION. To compound mercury (quicksilver) with another metal. In Electro-Physics, the term is usually applied to the covering of the zinc plates with mercury, by first pouring over them an acid solution and then dipping them in mercury, or pouring it over them.

ANELECTROTONOS. The phase of *diminished irritability* which appears at the positive pole when a nerve is in the electrotonic condition (p. 53).

ANIMAL ELECTRICITY (p. 46).

ANIONS. In electrolysis the electro-positive substances that go to the cathode (Faraday) (p. 625).

ANODE (ἀνά, upward, and ὁδός, way). Where the current enters, called also *positive* or *copper pole* (Faraday).

ANTOZONE (p. 607).

APPARATUS. A contrivance or combination for a certain purpose; often used synonymously with *machine* or *battery*. Strictly, however, apparatus is applied only to the more simple contrivances, and machine to the more complex.

ARMATURES. Bars or *keepers*, which, when placed in contact with the pole of a magnet, preserve its magnetism.

ASCENDING. From periphery toward the centre, applied especially to the nervous system.

ATMOSPHERIC ELECTRICITY (p. 93).

BATTERY, ELECTRIC (or galvanic). A *series* of Leyden jars, or (more frequently) elements, connected together. The term is applied, however, to a *single* element, and incorrectly also to a machine or apparatus.

BATTERY CURRENT (see Galvanic current).

BOUND ELECTRICITY. Electricity in the Leyden jar (p. 18).

CATALYTIC. Pertaining to catalysis.

CATALYSIS (κατά, and λύσις, from λύω, to disengage). The absorption, and the accompanying transference of liquids caused by the chemical action of the galvanic current (Remak). Strictly speaking, the condition of extreme polarization.

CATELECTROTONOS. The phase of *increased irritability* which appears at the negative pole when a nerve is in the electrotonic condition (p. 53).

CATHODE (cat-ode) (κατά, downward, and ὁδός, way). Where the current passes out; called also *negative* or *zinc pole* (p. 625).

CATIONS. In electrolysis, the electro-negative substances that go to the anode (Faraday) (p. 625).

CELL (see element).

CENTRAL ELECTRIZATION.* Electrization of the brain, spinal cord, and sympathetic.

CHEMICAL GALVANO-CAUTERY. (See Electrolysis, and p. 643.)

CHRONOSCOPE AND CHRONOGRAPH (χρόνος, time, and σκοπεῖν, to observe). Instruments for measuring and recording the velocity of the nervous force, electricity, etc. (p. 90).

CIRCLE GALVANIC (p. 20).

CLOSING CONTRACTIONS. Contractions produced at the closing of the circuit.

COERCITIVE FORCE (p. 6).

COIL INDUCTION. Rolls of wire in which the current is induced by the alternate opening and closing of the circuit, as Ruhmkorff's coil (see Induction).

COMMUTATOR. An arrangement for reversing the current (Ferguson).

CONDENSER. An apparatus for condensing a large quantity of electricity on a small surface.

CONDUCTING WIRES. The wires that conduct the electricity from the machine to the electrodes (p. 140).

CONDUCTIVITY (or conductibility). That property by which a body conducts electricity.

CONDUCTOR. That which conducts electricity. Sometimes used for *electrode*.

CONSTANT CURRENT. The galvanic current from elements with two liquids. The constant batteries that are best known are those of Daniell, Grove, and Bunsen (p. 26). Applied also to the *galvanic current* in general, and used synonymously with *continuous*. It is sometimes prefixed to galvanic current (constant galvanic) in the sense of *uninterrupted* (see Galvanic current.)

Continuous. Constantly flowing in one direction, sometimes used in the same sense as *constant*, or *galvanic*. Strictly, it should be applied to the uninterrupted galvanic current, since the faradic current is always interrupted (see Galvanic current).

Continuous Electrization.* This term might appropriately be applied to the protracted applications made by galvanic disks, belts, chains, poultices, &c., worn on the body.

Contractility, Electro-Muscular. That property of muscles that causes them to contract, when acted upon by the electric current. It is to be distinguished from irritability, which it includes. Electro-muscular irritability may exist in muscles that have wholly lost their electro-muscular contractibility. (See Irritability.)

Copper Pole (see Positive pole).

Current Changer (see Current reverser).

Current, Electric. The continuous discharge and electricity that result from chemical action, such, for example, as takes place in any ordinary element.

Current Increaser.* A contrivance for increasing the strength of the current *without breaking the circuit.*

Current of the Pile (see Galvanic current).

Current Reverser. An arrangement for reversing the current.

Current Selector. A contrivance for bringing any desired number of elements into the circuit.

Cylinder Machine. A form of machine for generating statical electricity.

Declinometer. An instrument for measuring magnetic declination. The *mariner's compass* is a declinometer.

Density. Compactness. The density of a current, other conditions being the same, is in proportion to the smallness of the electrodes. Sometimes used for *Intensity.*

Descending. From the centre toward the periphery.

Diamagnetism. That property of bodies by which they manifest the same magnetic phenomena as iron.

Dielectric. A medium through which induction is propagated.

Diplegic Contractions (p. 65).

Dipolar Arrangement (p. 52).

Dipping Needle. A needle for measuring the magnetic dip.

Direct Current (see Descending current), also used for *galvanic* current (see Galvanic current).

Direct Electrization (p. 161).

Dry (or cutaneous) **faradization.** Faradization with dry electrodes (p. 160).

Dynamical Electricity. Voltaic electricity. Electricity in *motion.* Generated by chemical action, as in the voltaic pile, or in any cells.

Electric (or electrical). Pertaining to, derived from, or containing electricity.

Electrics. Those substances which, when held in the hand and rubbed, become electric.

Electric Bath (p. 241).

Electric (or metallic) **brush.** A wire brush used as electrode.

Electric (or galvanic) **disks** (p. 132).

Electrician. One who studies electricity in its *physical* relations; oftentimes used erroneously for electro-therapeutist.

Electricity (ἤλεκτρον, amber). A powerful physical force, supposed to be due to molecular action, which is variously manifested, by attractions and repulsions, by thermic and luminous effects, by shocks, &c. It is developed by friction, pressure, chemical action, heat, and magnetism. Electricity is correlated to the other great forces,—light, heat, gravitation.

Electrify. This term is usually applied to the use of statical electricity, and is therefore synonymous with franklinization. It is sometimes used synonymously with electrize.

Electric Hand. The hand used as an electrode in electrization.

Electric Moxa (p. 160).

Electric Points.* Points on the body where, for anatomical reasons, electrization is particularly effective (p. 250); a more general term than motor points, and includes it (see Motor points).

Electrization. The act of electrizing. The term includes faradization, galvanization, and franklinization, or the application of statical electricity.

For the sake of uniformity, and in order to preserve the distinction between the different methods of application, *electrization* has in this work usually been preferred to the periphrastic expression—the use of electricity.

Electrize. To affect by electricity.

Electro-Anæsthesia.* The production of the local anæsthesia by the application of electricity (p. 61).

Electro-Chemistry. Electricity in its relations to chemistry, of which electrolysis is a branch.

Electro-Chemical. Pertaining to electro-chemistry.

Electro-Chemical Bath (see p.).

Electrode (ἤλεκτρον and ὁδός, way). The way by which the positive and negative electricities emerge. The positive pole is connected with the *negative* metal of the element, and the negative pole is connected with the positive metal.

Electro-Diagnosis. The use of electricity as a means of diagnosticating disease (p. 259), called also *electro-pathology*.

Electro-Dynamics. The phenomena of electricity in motion. Especially applied to the material attractions and repulsions of currents on currents, and currents on magnets (Ferguson).

Electrolysis (ἤλεκτρον and λύω—through λύσις, disengaging). The act or process of decomposing a compound substance by electricity.

Electrolyte. A substance which is susceptible of electrolysis.

Electrolytic. Pertaining to electrolysis.

Electrolyze. To decompose a compound substance by the action of electricity.

Electrolyzation. The act of electrolyzing.

Electro-Magnet. A bar of soft iron which, under the influence of the galvanic current, becomes magnetic.

Electro-Magnetism. The phenomena of magnetism produced by an electric current.

Electro-Medicine. Electricitry in its relations to medicine; called also electro-therapeutics.

Electro-Medical. Pertaining to electro-medicine.

Electro-Medication.* The introduction of medicines into the body by means of electricity (p. 679).

Electrometer. An instrument for measuring the charge of a battery.

Electro-motive force. "The power or course by which electricity is set in motion in the voltaic circuit" (Ganot).

Electro-motor. The metals that generate an electric current.

Electro-Otiatrics. The electro-physiology or electro-therapeutics of the ear (p. 550).

Electro-Pathology (see electro-diagnosis).

Electrophorus. A contrivance for collecting electricity by induction.

Electrophorus Machine (p. 16).

Electro-Physics.* Electricity in its physical relations (p. 3).

Electro-Physiognomy * (p. 244).

Electro-Physiology (p. 45).

Electro-Physiological Anatomy * (p. 244).

Electro-Physiologist. One who studies electricity in its physiological relations.

Electro-Puncture. The application of electricity (galvanic, faradic, or franklinic) by needles introduced beneath the surface.

Electroscope. An instrument for detecting the presence and the character of electricity in a body.

Electro-Sensibility.* Sensibility of the body to electricity (p. 254).

Electro-Surgery. The use of electricity, of any form, in surgical diseases includes *galvano-surgery*, Electro-Therapeutical Anatomy * (p. 250).

Electro-Therapeutics. The use of electricity of all forms to the treatment of disease. The term includes both medical and surgical electricity (electro-surgery); also *galvano-therapeutics* and *galvano-surgery*.

Electro-Therapeutist. One who studies electricity in its *Therapeutical* relations. Electro-therapeutists are frequently erroneously called Electricians (see Electrician).

Electrotonic. Pertaining to or derived from electrotonos.

Electrotonos. The modification which a nerve-current undergoes when acted upon by the galvanic current (p. 50).

Electro-Vital. Pertaining to animal electricity, which is dependent on *vital* processes.

Element (couple, or pair, or cell), Galvanic or Voltaic. Two heterogeneous metals immersed in acid solution. Thus we have Smee's, Grove's, Bunsen's, and Daniell's Elements, called also a *battery*, although strictly a *battery* means a series of elements.

Extra Current. The current which is induced by any coil of wire on the adjacent coils of the same wire (p. 37).

Extra-polar. Not included in the intra-polar region between the poles (p. 54).

Faradic (Faraday) current. The induced current (p. 34). The term is applied both to the *electro-magnetic* and *magneto-electric currents*, since they were both discovered by Faraday. Called also *secondary, interrupted, induced, inductive, to and fro, indirect, electro-magnetic*, and *magneto-electric*. *In this work the term faradic has been uniformly adhered to.*

Faradism. The phenomena of the faradic current. Sometimes used for *faradization*.

Faradize. To affect by application of the faradic current.

Faradization. Affecting by application of the faradic current. (According to our highest authority in the orthography of this department of terminology—Mr. William Wheeler—*faradaization*, as derived from Faraday, would be more consistent with analogy than faradization. The latter mode of spelling the word has the twofold advantage that it has been long used and is the more simple, and accordingly we have retained it in this work and in all our recent writings.)

Farado-contractility. Contractility to the faradic current.

Farado-Electrolyzation.* The simultaneous use of faradization and electrolyzation.

Farado-puncture. Electro-puncture with the faradic current.

Franklinic. Pertaining to statical electricity (little used).

Franklinism (Franklin). The phenomena of statical electricity (little used).

Franklinization. The application of statical electricity (little used).

Frictional Electricity. Electricity generated by friction. It is one form of statical electricity, which is the wider term, including electricity generated by pressure or cleavage.

Galvanic Apparatus. Apparatus for generating and furnishing the galvanic current.

Galvanic Belt (p. 137).

Galvanic Chain (p. 137).

Galvanic Circle. Two metals in a liquid—the galvanic element, pair or cell *in action* is called also a *circuit* or *chain*. A circle may be *single*—one cell or pair; or *compound*—several joined together.

Galvanic Current. A current generated by chemical action and coming directly from the cell, pile, or battery in which it is generated; distinguished from the faradic current, that is induced on a coil of wires; called also *continuous, constant, direct, primary, current of the pile, battery current, and voltaic current.*

Galvanic (or Electric) Disks (p. 137).

Galvanic Pair (see Element).

Galvanic Pessaries (intra-uterine) (p. 500).

Galvanic Poultices (p. 137).

Galvanism. The science which treats of electricity that arises from chemical action; called also *voltaic* or *dynamical* electricity.

Galvanization. Affecting by application of the galvanic current.

Galvanize. To affect by application of the galvanic current.

Galvanist. One who uses galvanism (little used).

Galvano-caustic (see Galvano-cautery).

Galvano-cauterism. The application of the galvano-cautery (see Galvano-cauterization).

Galvano-cauterization. The act of burning or searing by a non-conducting-wire, heated by the galvanic current.

Galvano-cautery. Cauterization by a resisting wire (usually platinum), heated by the galvanic current; called also galvano-caustic, or *galvano-causty*.

Galvano-contractility. Contractility to the galvanic current.

Galvano-faradization.* The *simultaneous* application of the galvanic and faradic currents.

Galvanometer (or multiplier). An instrument for determining the presence and direction and measuring the quantity and approximate intensity of a current. It is frequently used by electro-therapeutists in order to ascertain the dose of the galvanic current that they are giving. It is, however, only an approximately correct guide.

Galvano-puncture. Electro-puncture with the galvanic current.

Galvanoscope (see Electroscope).

Galvano-surgery. The application of the *galvanic* current to surgery.

Galvano-therapeutics. The application of the *galvanic* current to therapeutics.

General Electrization * (p. 187).

General Faradization.* General electrization with the faradic current.

General Galvanization.* General electrization with the galvanic current.

Helix. The coil of wires of the electro-magnetic apparatus (p. 33).

Heteronymous Poles (ἕτερος and ὄνομα). Poles turned in the same direction (p. 5).

Hydro-Electrization.* The application of electricity by means of water as an electrode (p. 677).

Increasing Current.* An application in which the strength of the current is gradually increased without breaking the current, called also *swelling current*.

Indirect Electrization (p. 161).

Induced (or Induction, or Inductive) Current. As usually understood, the current which is induced in a coil of wires from another coil through which the current passes. Currents may, however, be induced in any metallic conductor from any other metallic conductor that is traversed by the electric current, or from powerful magnets, or from the magnetic action of the earth (p. 34).

Inducing Current. The current that gives rise to an induced current.

Induction. "The action which electrified bodies exert on bodies in the natural state" (Ganot). Both statically and dynamically electrified bodies are capable of inducing an electrical condition of a body near at hand. Magnetism also is capable of induction (p. 34).

Inductive (see Induced Current).

Intensity (or Tension). "The quantity of electricity which in any unit of time flows through a section of the circuit" (Ganot).

"The quantity refers to the number of particles electrified, and the amount of charge lodged in each; the tension has reference simply to the amount of force lodged in each." A particle that is charged with a large amount of electricity has a more powerful effect on the particles near it than those that are charged with a small amount, and will therefore sooner become discharged. Therefore it is that intensity practically defined is the property of electricity which overcomes resistance (p. 29).

Insulator (or Isolator). A bad conductor of electricity.

Insulated. Placed on non-conducting supports, or covered with some non-conducting substance.

Interrupted Current. Broken, intermitted. The faradic current is necessarily interrupted by the apparatus that generates it. The galvanic current may be either continuous or interrupted.

INTRA-POLAR. Between the poles (p. 54).

IONS. The constituents into which the electrolyte is decomposed (p. 625).

IRRITABILITY. That property of organized substances that causes them to respond to stimuli.

IRRITABILITY, ELECTRO-MUSCULAR. The property of muscular fibre that causes it to be excited to movement by the electric current. Electro-muscular irritability may exist without electro-muscular contractility; that is, the muscles may quiver or be spasmodically excited by even a mild current, even when they fail to contract under a very powerful current.

IRRITABILITY, PRIMARY, SECONDARY, AND TERTIARY. Degrees of irritability that are observed during a séance of galvanization (p. 555).

LABILE CURRENT (or application). An application in which one or both of the electrodes is moved or glided over the surface.

LEYDEN JAR. A glass bottle partially coated with tinfoil, for condensing statical electricity.

LOCAL ELECTRIZATION. Application of electricity to some part or organ, as distinguished from general electrization, in which the application is made all over the body. *Local* is practically synonymous with *localized* electrization, although, strictly speaking, localized implies that the direct action of the current is confined to the part to which the application is made, while local does not suggest any such meaning. According to this distinction, electrization may be local without being necessarily localized. For the sake of uniformity, the term localized has been generally adhered to throughout this work, to distinguish all local applications of electricity. (See localized electrization.)

LOCALIZED ELECTRIZATION (p. 158). (See local electrization.)

MACHINE (Electric or Electrical). Any mechanical contrivance that generates any form of electricity; also called *electric apparatus*, but strictly is more complex than apparatus. Thus, for example, we have Holtz's machine for statical electricity; Kidder's machine for the galvanic and faradic currents, &c.

MAGNETISM. The power which certain bodies possess of attracting iron (p. 3).

MAGNETIZATION. The act of magnetizing.

MAGNETO-ELECTRICITY. The current induced by a magnet, as in the magneto-electric or rotary apparatus. It is one form of the faradic current, of which the electro-magnetic is the other.

MAGNETOMETER. An instrument for measuring magnetic declination.

MAGNETS. Substances that have the property of attracting iron.

MOLECULES. The minuter particles of which bodies are composed. Electricity is believed to be a peculiar action of molecules on each other (p. 24).

MOTOR POINTS. Points on the body where the nerves and muscles most readily respond to electrization; more specific than electric points, which is a general term, and includes all forms of reaction to the electric current (p. 250).

MULTIPLIER. An instrument for multiplying or increasing a force—as heat or electricity. The term is applied both to the *galvanometer* and *current increaser*.

MULTIPLIER ROTATION (p. 17).

NEGATIVE MODIFICATION (p. 55).

NEGATIVE POLE. Where the current passes out; called also *zinc-pole* or *cathode*. The current is felt stronger at the negative than at the positive.

NEGATIVE VARIATION (p. 50).

NERVE-MUSCLE CURRENT (p. 183).

OPENING CONTRACTIONS. Contractions produced at the opening of the circuit.

OZONE (p. 605).

PARAMAGNETISM. That property of bodies by which they manifest magnetic phenomena opposite and corresponding to iron.

PARELECTRONOMY (p. 49).

PERIPHERAL ELECTRIZATION. Electrization of the periphery.

PERIPOLAR ARRANGEMENT (p. 52).

PERMANENT (or tonic) **EFFECTS OF ELECTRIZATION** (pp. 184, 222).

Pile-like Arrangement (p. 52).

Platinum (or Platina) (from Spanish platina, silver). A metal used in electrical researches.

Plexus-Nerve Current (p. 183).

Polar. Relating to the poles.

Polarity. That property of bodies by which peculiar phenomena of the positive and negative are exhibited at certain points. Polarity of a nerve is that condition of a nerve by which one part is exhibiting a positively and the other a negatively electric state.

Polarizable. Susceptible of polarization.

Polarization. The act of giving polarity to a body.

Polar Method. The method of application by which the distinctive and differential action of each pole is obtained, by placing one pole over the part to be affected and the other in some indifferent point; called also *unipolar*.

Polarize. To communicate polarity to.

Polarizing. Giving polarity to.

Polarizing Current. The current that produces the electrotonic condition.

Poles. Points where magnetism is concentrated, or where the electric current passes in or out. The terms *positive* and negative are relative, not absolute, since their position varies with the relative position of the electrodes.

Positive Modification (p. 55).

Positive Pole. Where the current enters, called also *copper pole* or *anode* (p. 625).

Primary Current or Inducing Current. The current that passes through the inner coil of wire in a helix, and that induces a current on the coil that surrounds it (p. 36). Used erroneously as synonymous with *galvanic* or constant current.

Primary Effects of Electrization (pp. 184, 222).

Protracted Applications.* Applications that are made for a very long time. Applications of galvanic belts, disks, and poultices are protracted.

Quality of a Current, as distinguished from quantity and intensity, refers to its smoothness or harshness, or to the rapidity or slowness of interruption.

Quantity. The amount of electricity that is generated. It is proportioned to the amount of chemical action that takes place (p. 29). Quantity is obtained by large surface of metals, and strong acid solutions (see Intensity).

Electric Reaction. The phenomena developed by any part of the body under the influence of electricity.

Reaction (galvanic). (See Electric reaction.)

Resistance. The opposite of conductivity. That property of bodies that makes them resist or oppose the passage of the current.

Reverse Current. (See Ascending current.)

Rheocord. An instrument for controlling the fluctuations of the current (p. 71).

Rheomotor. (See Electromotor.)

Rheotome (ῥέω to flow, and τέμνειν, to cut). A current breaker (p. 120).

Rheostate (or Rheostat) (ῥέω to flow, and στατος, standing still). Instrument for regulating the strength of the currents by interposing resistances that may be graduated by units (p. 552).

Rotary Machine. Magneto-electric machines, in which the electricity is generated by turning a crank.

Secondary Closure (p. 269).

Secondary Current. The faradic current, called also the *interrupted, induced, inductive electro-magnetic, faradic,* etc.

Secondary (or Reactive) Effects of Electrization (pp. 184, 222).

Sensibility, Electro-Muscular. The peculiar subjective sensation which is experienced by the contraction of a muscle under the electric current.

Shock. A sudden single discharge of electricity, such as is given from a Leyden jar, or apparatus for statical electricity.

Spark, Electric. The spark that attends the discharge of electricity on the passage of the current from one conductor to another.

Spinal-Cord Current (p. 181).

Spinal-Cord-Muscle Current (p. 183).

Spinal-Cord-Nerve Current (p. 182).

Spinal-Cord-Plexus Current (p. 182).

Spinal-Cord-Root Current (p. 181).

Stable Current (or application). An application in which both electrodes are kept in a fixed position.

Statical Electricity. Electricity in *rest*, generated by friction, pressure, or cleavage.

Stimulating effects of electrization (pp. 122, 184).

Strength of the Current. "Amount of chemical action that takes place in a given time" (Ferguson). This term is vaguely applied either to quantity or intensity, or to electro-motive force. In electro-therapeutical language it is practically that quality of the current, intensity or quantity, or electro-motive force, that is necessary for the purpose in hand.

Swelling Current (see Increasing current).

Tension (see Intensity).

Tetanization (p. 49).

Thermo-Electricity. The electricity that is generated by heating two heterogeneous conductors at their point of junction (p. 49).

To-and-Fro Current (see Faradic current).

Uniform Current.* A current that is kept at the same strength during the application.

Unipolar Method or Application. One pole on the part that is to be affected, and the other on some indifferent point; called also polar method.

Uninterrupted. Unbroken, Continuous (see Continuous). Applied only to the galvanic current, since the faradic is always interrupted by the machine that generates it.

Unit. An abstract term to express any determined quantity, by the repetition of which any other quantity of the same kind can be measured (Olmsted). "A *unit of heat*, for example, is the quantity required to raise the temperature of one gramme of water at its maximum density by 1° C." (Ferguson). Various standards have been proposed—pure mercury, one metre long with a section of a square millimetre; and a standard mile of a *special* copper wire of an inch in diameter. Seimen's unit of resistance, by which the rheostate (p. 552) is constructed, is a prism of pure mercury, one metre long and one millimetre square in section, of the temperature 0° C.

Unpolarizable. Not susceptible of being polarized (p. 140).

Variations of the Needle (p. 9).

Volta-Electric Induction (see Induction).

Voltaic Alternatives. Changes in the direction of the galvanic current.

Voltaic Pile or Battery (Volta). A series of elements so arranged that the zinc of one element is connected with the copper of the other.

Voltaic Current (Volta) (see Galvanic current).

Voltaism (see Galvanism). (Although the honor of giving the name to electricity generated by chemical action is really deserved both by Volta and Galvani, and has, to a certain extent, been accorded to both, yet the term galvanism with its derivatives has practically secured an ascendency which it will probably retain.)

Voltameter. An apparatus for testing the strength of the current by measuring the quantity of gas given off in a given time during the decomposition of water

Zinc Pole (see Negative pole); called also *cathode* (p. 625).

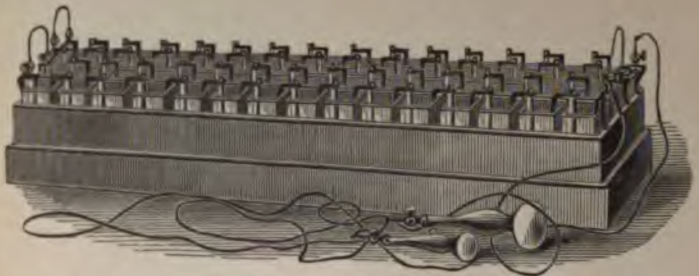


FIG. 95.—DIVISIBLE COMBINATION OF SIXTY SMEE'S ELEMENTS.

This combination of Smee's Elements is designed for hospital or office use. Although it can be carried by two persons, it is yet not conveniently portable; and therefore we have suggested the plan of *dividing* it into sections of 20 elements each. One or two of the sections may be provided with a cover and strap, and may be carried in the hand for a short distance without difficulty. We have also devised a simple arrangement for increasing the current without breaking the circuit, and have suggested other improvements in the details of the construction of the apparatus that will somewhat diminish its inconveniences, and make it more generally acceptable. It is a great advantage to have the apparatus connected with the ingenious contrivance of Kidder for increasing, interrupting, and reversing the current (see p. 135). Special directions accompany the apparatus.

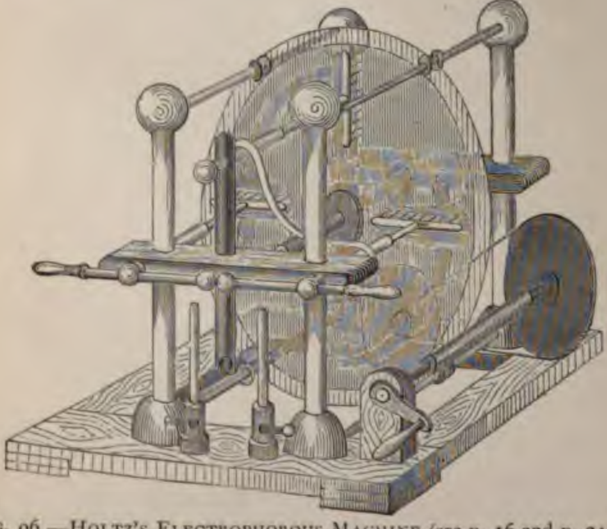


FIG. 96.—HOLTZ'S ELECTROPHOROUS MACHINE (see p. 16 and p. 241).

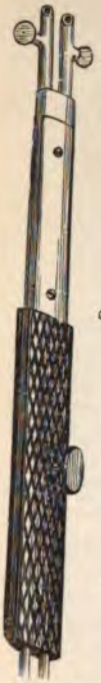


FIG. 97.

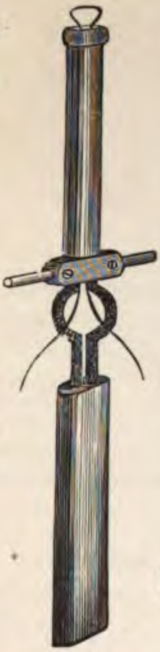


FIG. 98.

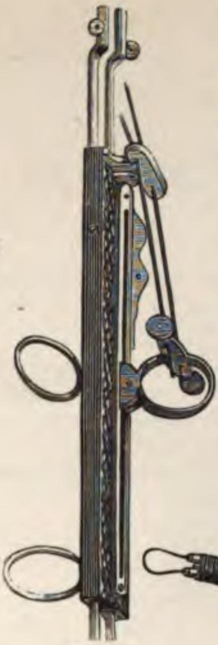


FIG. 99.

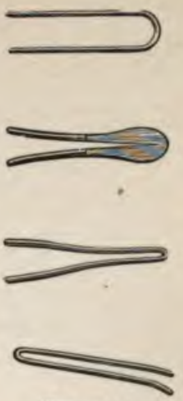


FIG. 100.

BURNERS AND CUTTING-LOOPS FOR GALVANO-CAUTERY (BRUNS).
(See p. 617.)

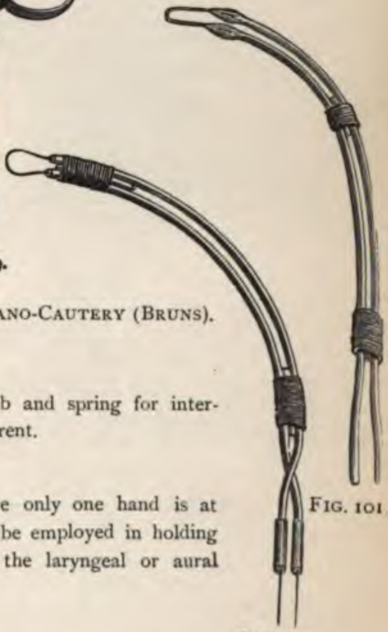


FIG. 101.

FIG. 102.

FIG. 97.—Handle for Burner, with knob and spring for interrupting or connecting the current.

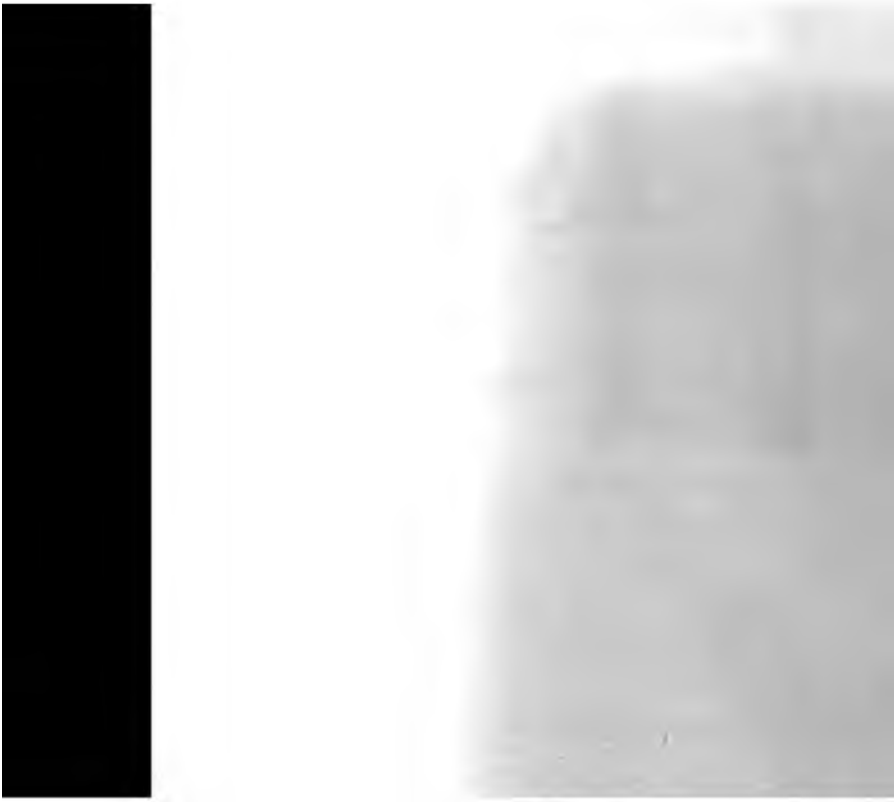
FIG. 98.—Handle and Cutting-loop.

FIG. 99.—Handle for Cutting-loop where only one hand is at liberty; the other hand may be employed in holding some other instrument, as the laryngeal or aural mirror.

FIG. 100.—Burners of various shapes.

FIG. 101.—Burner for larynx.

FIG. 102.—Cutting-loop for larynx.



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